

**Group Technology/Flow  
Applications in Production Shops**

U.S. DEPARTMENT OF TRANSPORTATION  
Maritime Administration and the U.S. Navy

in cooperation with

National Steel and Shipbuilding Company  
San Diego, California

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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM  
THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS  
SHIP PRODUCTION COMMITTEE  
PANEL SP-1  
SHIPYARD FACILITIES & ENVIRONMENTAL EFFECTS

GROUP TECHNOLOGY/FLOW APPLICATIONS  
IN PRODUCTION SHOPS

FINAL REPORT

TASK 1-83-5

SUBMITTED TO:  
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Date: February 1988

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## PROGRAM MANAGEMENT

This report is one of the many projects managed and cost shared by the National Steel and Shipbuilding Company, under the auspices of the National Shipbuilding Research Program. The program is a cooperative effort between the Maritime Administration's office of Advanced Ship Development, the Navy and the U.S. shipbuilding industry.

Executive administration and supervision were provided by Mr. James R. Ruecker, Chief Manufacturing Engineer and Mr. Lynwood P. Haumschilt, Manager Facilities and Maintenance, NASSCO.

Project definition was provided by the members of the Society of Naval Architects and Marine Engineers Panel SP-1 Shipyard Facilities and Environmental Effects and the authors of the technical papers presented.

## BACKGROUND

Group Technology has been in use since the mid-1920s in a number of U.S. industries other than shipbuilding. The Europeans and Japanese have been applying the concept to shipbuilding since the 1950s. Since the introduction in the 50s in Japanese yards they have adapted it to their culture and carried Group Technology to its fullest potential. This has been confirmed by observation of their methods of fabrication assembly and installation.

In the last ten years a number of articles and guides have been written plus workshops have been held on how to apply the concepts of Group Technology to U.S. shipyards. The actual application of these techniques has only occurred in a few areas, primarily in the Steel Fabrication and Assembly functions.

## OBJECTIVES

The goal of this project is to apply the Group Technology concepts in areas not already addressed.

The application of Group Technology techniques can lead to reduced labor costs, improved material flow and handling methods, reduced space requirements not only for operational activities, but also for support activities such as storage. The end result will be better managerial control of the operation to meet the demands of the industry.

## APPROACH

Group Technology is applicable across a wide spectrum:

- . Product, Part, Assembly or Materials Coding
- . Cost Retrieval Coding
- . Product Categorization
- . Work Center Identification
- . Shop Planning and Control
- . Shop Loading
- . Shop and Work Center Capacity
- . Material Flow
- . Shop and Work Center Layout.

The primary objective of the concept is to complete similar work at the same work center repeatedly, using the same people, techniques and equipment.

### BENEFITS

The actual application of the Group Technology techniques demonstrates to the shipbuilding industry that such a concept is applicable in a shipyard environment. It has been proven in American factories and foreign yards that the use of Group Technology can yield better utilization of manufacturing resources:

- . Men
- . Material
- . Facilities.

## **FOREWORD**

Group Technology is one of the superior techniques which has become established in manufacturing technology in recent years. In the last three decades we have seen machines replacing manpower, mechanization, numerical control, automation, robotics and computer integration. These technologies don't exist by themselves, and neither does Group Technology. But Group Technology is a system that substantially adds productivity to small lot production--economic order quantities of one or a few--and it is an idea whose time has come, especially in shipbuilding.

To embrace all the significant areas where Group Technology has shipbuilding application is impossible within the scope of this project. However, with three specific subjects a range of possibilities are covered.



## **CONTENTS**

1. Group Technology and Shipbuilding, William S. Oakes, P.E.
2. Concepts and Methods for Classification and Coding Systems, H.B. Bongiorni.
3. Cellular Approach to Valve Repairs, W.O. Appleton.

Appendix - Advance Notes on Cellular Manufacturing, Parts 1 and 2, Vincent F. Bobrowicz, Manufacturing Technology Services, Inc.

FINAL REPORT  
FOR  
GROUP TECHNOLOGY/FLOW APPLICATIONS  
IN PRODUCTION SHOPS  
TO  
SNAME/SHIP PRODUCTION  
PANEL SP-1 FACILITIES

INTRODUCTION

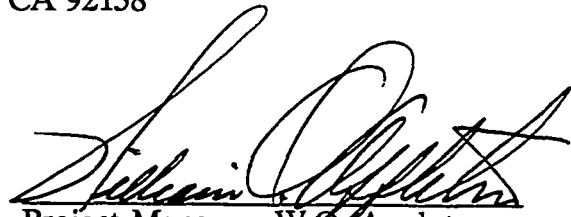
DEDICATION

We wish to mark the passing of William S. Oakes, Jr. who initiated this project and managed the overall effort until his death on September 27, 1987.

Bill's constant interest and actions in finding and developing new technology that could enhance ship production and repair efficiency has been most appreciated. We who worked with him shall continue to benefit from his work and thought.

In his memory, we dedicate this publication.

BY:  
NATIONAL STEEL AND SHIPBUILDING COMPANY  
HARBOR DRIVE AND 28TH STREET  
SAN DIEGO, CA 92138



Project Manager: W. O. Appleton,  
for W. OAKES, P.E.

## I Introduction and Definition of Group Technology and Process Lanes.

There are several definitions of Group Technology and the less sophisticated Process Lanes. Only Group Technology has an IIE official definition:

"An engineering and manufacturing philosophy which identifies the "sameness" of parts, equipment or processes. It provides for rapid retrieval of existing designs and anticipates a cellular type production layout."

Other definitions include more details. Heyer and Wemmerlov (1) use the following:

"Group Technology is an approach to manufacturing that seeks to maximize production efficiencies by grouping similar and recurring problems or tasks . . . . . it save time, avoids duplication and facilitates easy and timely information retrieval and use. An important part of Group Technology is the use of a code that -- like a library reference system -- serves as an index to characteristics in manufacturing, engineering, purchasing, resource planning, and sales to improve productivity in each of these areas.

J.F Lardner (2) says in his conclusion

"we can see what we should have recognized before. If you have 10,000 parts and you make them in 10,000 different ways, you will have a far greater management and control problem than if you identify 20 part families and are able to make them in only 500 different ways. In reducing the complexity of the manufacturing problem, the probability of errors and omissions is reduced."

Dick Price (3) states the following

"The Process Lane concept means very simply the categorization and separation of "like" kinds of work and the subsequent development of work centers specifically designed to efficiently and economically produce that kind of work. Process Lanes establish the greatest amount of "Learning Curve" efficiency by having the same people at the same work centers doing repetitive types of work every day with the support of a well organized and efficient flow of material."

Process Lanes are still a new concept.

There are many ways to implement Group Technology. Please bear with us, see how different people implement it and start thinking how you can apply it to your own advantage and profit.

## II Benefits to Users

It is most likely that Group Technology techniques have been used for several decades, as early as 1925. The modern forms first appeared in Russia, followed by England in 1972 (4). Dr. Inyong Ham (5) described it in 1976.

Without any priority or special order, here is a list of advantages that the shipbuilder can expect when using Group Technology techniques. We will emphasize the advantages of most interest to us.

- L The cell (either a physical layout or a planning layout) places a new way of thinking before us regarding flow-through production and planning that we did not have before. The design-production integration concept will be strengthened and encouraged by Group Technology.
- 2. Reduced lead time, setup time, and production time are all important, but also included is a more predictable, shorter schedule.
- 3. People in the organization develop "ownership" of the production concept. They work on a complete fabricated product and tend to build better quality. Inspection incorporated into the last step of this "mini-shipyards" insures better products, which, if necessary, can be fixed on the spot.
- 4. Production planning and control are simplified by calling out only one step rather than several -- and the one step might be more reliable compared to the many, unplanned, often disorganized steps in the shop.
- 5. This Group Technology system with its easy capability of handling single items or batch production matches the probable future strategic requirements of shipbuilding where we may expect more and more single order quantity ships.
- 6. Group Technology encourages a way of managing and working that matches the newer way of working. This is more compatible with the modern ways of training workers.
- 7. Parts visibility. Again the "grouping" of like or similar parts encourages industrial engineers and others to look at the quantity and numbers and suggest production improvements that they would not have thought of when the parts were in isolated, small batches.
- 8. The inherent design nature of manufacturing cells reduces the amount of material handling and the distance travelled by the parts as they are processed through the shop. The reduced distance minimizes the number of lost, misplaced, or misdirected parts. Less work in process than before.

9. A primitive Group Technology line is easy to setup, incorporating two stations as an initial installation and adding other stations later on. It is easy to get it going.
10. The examination process, or classification, often forces a mode of thinking that improves methods analysis, value analysis, work simplification and quality improvement.
11. Reduced Work in Process (WIP). Because the parts feed from one simple work station to the next, the cost of having batches of parts queued at each step is reduced, also resulting in less material handling.
12. Because of the better utilization of production facilities, the facilities cost can be lower.
13. In combination with numerical control (NC) machines, a Group Technology cell can feed parts into the machine, and with its planned tooling and setup for similar parts, the expensive machine can have better utilization and consequently better Return On Investment (ROI).
14. Reduced material handling and storage frees up floor space for production space.
15. Group Technology is compatible with and supports the Just In Time (JIT) concept. Normally you produce today only what you need today.
16. Engineering also gains in a number of advantages:
  - . Reduces the number of part designs.
  - . Helps quick retrieval of existing designs for design help and cost estimating.
  - . Exploiting Group Technology will involve engineering and production people more than ever before. The Group Technology data base has something for both functions.
  - . The visibility of grouped parts lets engineering see them. It is easier to incorporate existing parts, encourage combinations, or modify standard designs - all these functions usually reduce cost.
17. Procurement. Depending on the type of cell with its grouped parts, the procurement order quantities may be larger to serve several components and there will be fewer purchase orders.

18. Understanding of the production process is improved. As a worker sees the preceding steps and what follows, it is easier for him to understand the operation. When the other stations are separated by time and location, it is harder to understand.
19. Cost justification is easier to achieve when the equipment is amortized over a larger product base -- in fact, over the life of the cell rather than the duration of the part. Total facilities cost may be less.

## In Classifying and Coding

As you develop your concept of Group Technology you may want to improve your data retrieval methods. They may range from a simple, in-the-brain, classification using English words to a multiple digit code and a PC (personal computer) to manage it.

Coding is an interesting subject and the taxonomy of classification is one of the fundamental technical subjects. Using coding to classify and retrieve information does not have to be any more complicated than your needs are. Many people get along fine with intuition. Just be sure that you install a system that will meet your needs in the years to come.

Here are a few other observations (with an occasional repetition):

- . Coding helps keep track of parts and funnels the individual parts into your cells.
- . Some shops which make a lot of parts, classify them by laying them out on the floor, grouping them up, and taking scale photographs to give an idea of the mix.
- . A family-of-parts concept usually means common materials that normally require the same cutting tools, machines, and coolant.
- . After you have a collection of parts, look for the fundamental sameness of the various parts, classify them into groups and if the number of parts is large, consider using a computer based system (6).
- . In 1982, Dr. Ham did a survey on uses of classification techniques. He found that 48% used no classification (beyond intuition), 27% used an in-house code, and 25% used a commercial system.

A separate section of this report deals with the theory of classification and coding.

#### IV Cell Technology

As you go through the steps of Group Technology you start out by inventorying your parts, classifying and coding them into practical groups, and then routing them into the proper cell.

The cellular installation is the productive heart of the production facility.

Here are some of the cell attributes:

- . Your basic design technique should maximize your reliability and up time .... A broken down station has far reaching consequences.
- . The various stations should be close to one another, returning on themselves so that the finished part completes near where it started . . . . A semicircular shape is often used. Short, quick stations are best, but string them out if that is handy for you.
- . Assign one foreman to the cell.
- . Add workers according to the daily production schedule -- and just enough according to your engineered labor standards.
- . You can run the schedule up by adding more people if necessary. The basic objective is to build parts just-in-time, no inventory, and capture costs on completed units.
- . Remember that there is no best cell configuration. Only you know what is best for you -- and you might redesign the cell as your requirements go up or down.
- . A special cell might be the Flexible Machining System (FMS). Our Group Technology cell could increase the efficiency of the FMS by handling data, material, tooling and setup, and second operations so these would not have to encroach on the time of the very expensive machine tool.
- . If your cell is handling precision assembly or accurate placement, consider a palletized, shot pin located, carrier. It can do a more accurate and more inexpensive job if you need the locating attributes a pallet brings. The pallet also facilitates carrying more than one design or adding a new design later on.
- . Remember that a cell may be a concept.... Especially at first, you may not necessarily have to involve the physical arrangement of your facility.

- . It is not important to establish cells for all your production. It is likely that Pareto's Law will hold in your shop also and 80% is a good practical maximum.

You do not have to put off incorporating Group Technology. It is not difficult to get going in a limited way. Obviously, the more you incorporate, the greater the advantages and the greater the savings.

This report has concentrated on some observations regarding Group Technology. But more importantly when it comes to using Group Technology and generating the profit that can come from it is to use your tried and true implementation techniques. You must involve everyone who will have a part in installing or using a Group Technology line. Get their suggestions and contributions. Make it a team effort.

#### v Planning and Scheduling with the Cell

Depending on the shipyard the detailed planning will vary from a lot of detail to, as is usually the case, a little. But in any case the planners and schedulers will need to use the Group Technology Cell. They will find the simple cell easy to describe (for planning) and quick to schedule (because it gets in and gets out quickly).

As Tooling and Production stated in the March 1986 issue, "Technology has no intrinsic values. Its value depends on how well it is implemented", and used. Technology will not save our failing industries unless it is properly applied.

#### VI Examples of Group Technology Installation

- a. NASSCO Valve Line. (See extensive report on this project).
- b. NASSCO Sheetmetal Shop.

The next two pages show an example of one Group Technology project at NASSCO. Most of you are familiar with the 1-1/2 x 1/8 angle iron flanges that are used with most sheetmetal assemblies. Note the hedge-podge flow on the first page.

Our Group Technology version is on the second page. Note the simplicity.

After we accomplished the change, this is what we achieved (please see last page).

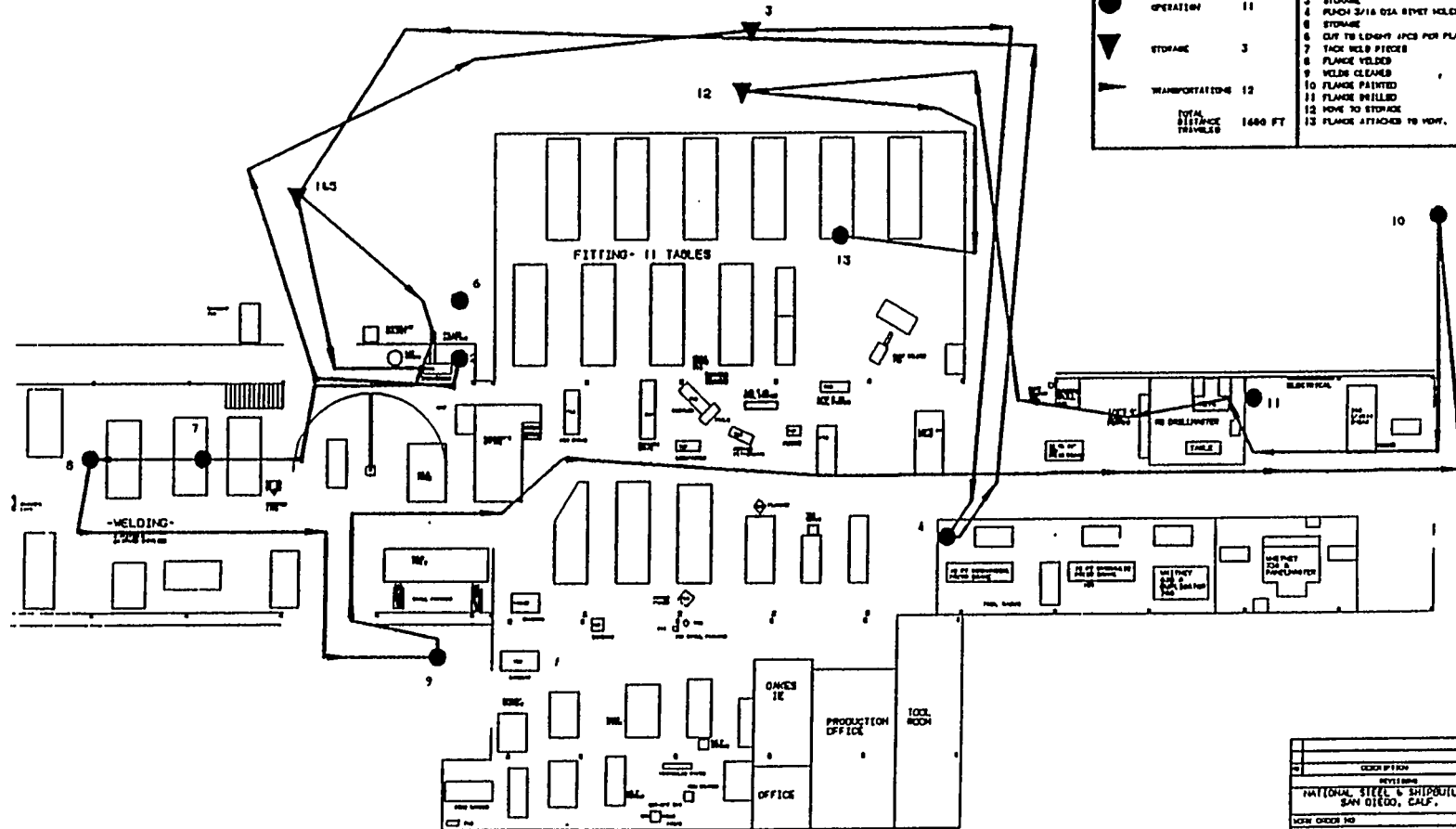
In addition to the expected higher productivity we expect to achieve:



# EXISTING FLOW PROCESS FOR VENTILATION FLANGES

CHART SUMMARY		LEGEND
● OPERATION	NUMBER OF OPERATIONS 11	1 STORAGE WHILE TYPING
▼ STORAGE	3	2 CUT INTO 18" X 18" LENS
→ TRANSPORTATION	12	3 STORAGE
TOTAL DISTANCE TRAVELED 1600 FT		4 FLANG 3/16 DIA 8" HET HOLE
		5 STORAGE
		6 CUT TO LENGTH & PCE FOR FLANGE
		7 TACK WELD PIECES
		8 FLANGE YOLDED
		9 WELD CLEANED
		10 FLANGE PAINTED
		11 FLANGE DRILLED
		12 MOVE TO STORAGE
		13 FLANGE ATTACHED TO BODY.

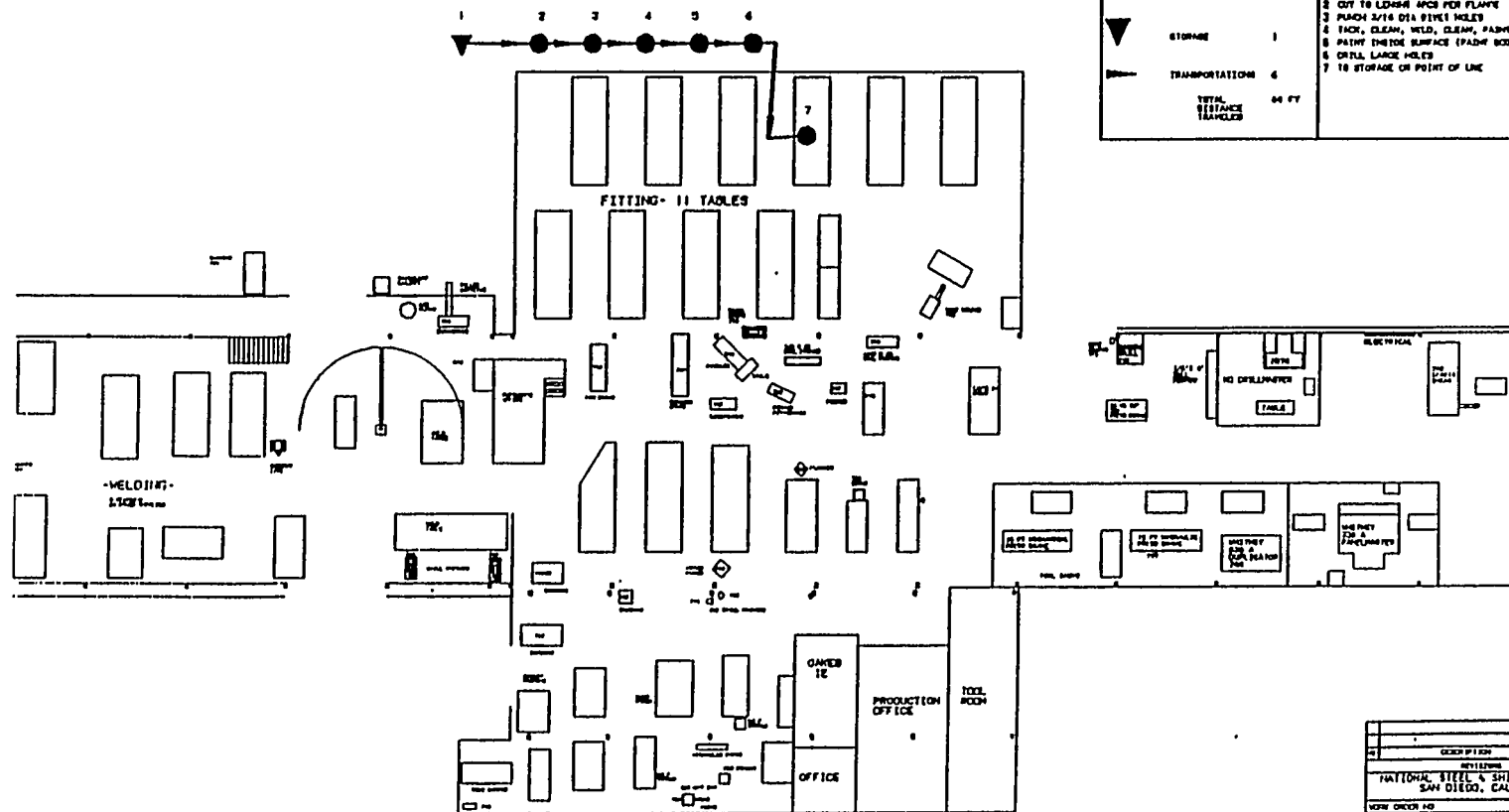
15



ORDER NO.	DATE
NATIONAL STEEL & SHIPBUILDING CO. SAN DIEGO, CALIF.	
NOW ORDER NO.	
BLOG 7 EXISTING FLOW PROCESS	
DATE	BY
SCALE 1/8" = 1'-0"	SHEET NO.

PROPOSED FLOW PROCESS  
FOR VENTILATION FLANGES

CHART SUMMARY		LEGEND
●	OPERATION	1 STORAGE AREA 100'
▼	STORAGE	2 CUT TO LENGTH APON FOR FLANGE
→	TRANSPORTATION	3 PUNCH 3/16 DIA STEEL HOLES
		4 TACK, CLEAN, WELD, CLEAN, PAINT
		5 PAINT INSIDE SURFACE (PAINT BOTTOM)
		6 DRILL LARGE HOLES
		7 TO STORAGE OR POINT OF USE
TOTAL DISTANCE TABLES		64 FT



DATE	BY
DESIGNED BY	DATE
CHECKED BY	DATE
NATIONAL STEEL & SHIPBUILDING CO. SAN DIEGO, CALIF.	
BUDG 7	
PROPOSED FLOW PROCESS	
DATE	BY
DATE	BY
DATE	BY

1. Just-in-time so that the flange is ready exactly when needed-- neither too soon (storage problems), nor too late (holds up schedule).
2. No lost flanges. When complete they go to the assembly.
3. Reduced clutter in the rest of the shop. Right now we have dozens of flanges and parts lying around.

## VII Caution

All the good qualities of Group Technology certainly recommend that the concept be given a good try. A few problems may appear, though, and it would be well to be alert.

- . Many of our shipyards have been very stable with little custom of improving methods or work rules. If this is the first project, be cautious.
- . A trade teaching system will probably be required if you are going to change the tasks of the journeymen to a Group Technology arrangement.
- . A production line, with or without Group Technology, will probably need line balancing. See to it. Find out about balancing if necessary.
- . Don't look for computer control for your Group Technology line. People make it work and you will need their effort and initiative. A Group Technology line operates in parallel with the computer.
- . Be careful about high quality designed cells. If you depend on your cell you must have it "up" all the time.
- . Remember that this system is pull system. It does not swing into action until the parts are needed.
- . Group Technology is not for free. You will need to do some financial justification to get this off the ground and involve the head office in "a new understanding".

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FINAL REPORT  
FOR  
GROUP TECHNOLOGY/FLOW APPLICATIONS  
IN PRODUCTION SHOPS  
TO  
SNAME/SHIP PRODUCTION  
PANEL SP-1 FACILITIES

JUNE 25, 1986

SUB-PROJECT  
CONCEPTS AND METHODS FOR  
CLASSIFICATION AND CODING SYSTEMS

BY  
NATIONAL STEEL AND SHIPBUILDING COMPANY  
HARBOR DRIVE AND 28TH STREET  
SAN DIEGO, CA 92138

  
Project Engineer, H.B. Bongiorno  


## ABSTRACT

In this paper, classification and coding will be discussed as a method for developing functional groups of similar product types. This is in contrast to other methods such as process analysis or manual/visual search. Application of more than one method is required in order to avoid errors introduced when only one method is relied upon. A review of statistical concepts of classes is introduced. A general approach to the development of a classification and coding scheme is presented. Two case studies are presented, the first dealing with shop applications, the second dealing with installation of steel outfitting items.

## Introduction

The subject of this paper is the development of classification and coding systems. The information in this paper is an overview of the general approach and tools required to create an effective class and code system. Much discussion has been given to the benefits of Group Technology. Classification and coding is often mentioned as an integral part of a Group Technology Installation. However, in the course of our work, we found details of "how to" develop a classification and coding system missing. In this paper, we hope to fill this gap in information.

## Discussion of Group Technology

Group Technology is a method where a job-shop manufacturing operation can make better use of its facilities and make management of operations easier by grouping similar work operations according to product similarities. The concept also provides production and engineering integration by exploiting the fundamental relationship that a product's geometric form is a function of the work processes applied to it.

## Method for Developing Groups

Group Technology depends on effective grouping of similar parts to form part families. The methods to do so are:

1. A manual/visual search
2. Production flow analysis
3. Functional sorting
4. Use of a classification and coding system
5. Use of computer techniques, for example cluster analysis.

Using a manual/visual search is the process of inspecting a collection of parts for similarities by intuitive comparison. This is limited in its effectiveness when a large number of parts are involved, but can be a good way to get started and get early involvement of supervision and operators in the project.

Production flow analysis is a process where parts that have the same manufacturing processes are grouped together. This can be effective, however, it can miss subtle differences between parts. Exploiting physical parameters is still required to achieve full group technology benefits.

Functional sorting is the method where parts are grouped by nomenclature describing part functions. Often different names can be given to the same parts making this unreliable.

Cluster analysis deserves some discussion at this point. This method of analysis and development of groups is an application similar to the one that is being presented in this paper. The major difference is the algorithm used in defining groups of similar objects. (1)

Cluster analysis is a complex statistical method that lends itself to computer applications. The methodology of cluster analysis is the systematic answering of the following questions:

1. What are the relevant or descriptive measures of an entity?
2. How do we measure the similarity between entities?
3. How do we form clusters?
4. How many clusters do we need?

For question one, no unique answer exists. That is, the choice of relevant descriptive variables requires knowledge of the things to be grouped and the objective of the grouping process. The answers to questions two and three are an application of statistical methods that calculate distances between entities and then optimizes the distance relationships to form groups. The last question is again up to the user of the system to identify what level of detail satisfies the needs of the grouping exercise.

Cluster analysis is a data analysis technique and not an interference technique. When the method arrives at a grouping there is no guarantee that what has been produced is a set of statistically significant groups.

The difference between the above procedures and classification and coding are subtle. The above cases all require some form of classification and coding structure. They are not used in the same manner but do not exploit the fundamental premise of Group Technology. That is the relationship between how a part is made indicates how the part looks. All of the above cases are subsets of a classification and coding method. To use any of the other methods for putting Group Technology in place requires some form of classification and coding. In the case of cluster analysis versus classification and coding, the latter requires the same questions to be asked, but uses different statistical methods to arrive at the answers to questions two and three. (2)

Classification and coding is the most popular method for creating part families and implementing Group Technology. The process is not just for developing part families, but is also the process of creating a database model of the manufacturing operation. It is an intimate part of the grouping procedures listed above. In G.M. Ranson's book Group Technology he makes the following claim.

"From all the foregoing, it can be clearly seen that the application of a properly designed classification and coding system can only result in extreme benefit. Moreover, the principle, procedures, and practices that are thus established can be extended to all company operations. Whereas it may be argued that a more simple



classification can be undertaken by determining from experience the aggregation of parts to form families which may perhaps be sufficient for the manufacturing process, it is very unlikely that such a simple approach will benefit the other facets of the operation, as a properly devised classification and coding will." (3)

### Benefits of Classification and Coding

Benefits of a well designed classification and coding system in general are those of Group Technology, hence the common confusion of classification and coding with Group Technology. Classification and coding is a more general process of developing a model of the manufacturing operation. Classification and coding covers many areas and is a precursor to Group Technology. Specific benefits are:

1. Formation of part families and machine cells (traditional Group Technology).
2. Effective design and process plan retrieval.
3. Design rationalization and reduction of design costs.
4. Standardization of design.
5. Development of reliable work histories.
6. Accurate estimating of machine requirements, rationalized machine loading, and better use of capital.
7. Reduction of set up time and overall production time.
8. Standardization of process plans and process routing.
9. Rationalization of production planning and scheduling.
10. Accurate cost accounting.
11. Better machine utilization and manpower allocation.
12. Improved NC programming.
13. Establishment of the company master database.

### Classification and Coding Methods

Developing a classification and coding system is a process of finding the characteristic variables that describe or measure the manufacturing process. This process also involves the use the system of description.

#### Classification

Classification is defined as "arranging items into groups according to some principle or system whereby like things are brought together by their similarities and are then separated according to a specific difference." (4)

In order to apply even the most basic forms of statistical analysis, some form of class structure must be hypothesized. For example, looking at a frequency distribution requires distinct classes in order to sort events or occurrences.

Development of a class structure is a form of measurement. Care must be exercised to apply the appropriate statistical method for the level of measurement being used.

In order to create a system that describes the process of measurement, a class structure is developed for a manufacturing operation. We are essentially measuring it. There are four levels of measurement: nominal, ordinal, interval, and ratio. We are most familiar with the ratio level of measurement. These are weight, length, time and other physical characteristics. However, the other levels are also familiar but we don't usually consider them measurement.

Nominal measurement is the development of a class structure. This is often considered classificatory measurement. This carries the least information about elements we are studying. In our applications, it is an improvement over none.

Ordinal measurement is a more developed level of measurement which is classificatory and also represents interrelationships of rank ordering. Using this level of measurement gives the ability to identify greater-than or less-than relationships or better/worse relationships.

The interval level of measurement conveys more information than the previous levels. It builds on the previous levels by being classificatory and rank ordering. Intends are arbitrarily defined at equal intervals with an arbitrary zero point.

Ratio level of measurement is the same as interval except that it has an absolute zero. This makes it possible to measure physical phenomena and relate rules of arithmetic to these phenomena. Examples are temperature, length, and time.

A definition of class used in statistics is as a category of interest. Classes are the grouping of observations. To do so, requires that class boundaries be set making a class mutually exclusive. That is, a piece of data can be placed in only one class. A class by statistical definition must be capable of containing all the data.

Class limits must be defined. It is desirable to select class limits so that actual observations are evenly distributed throughout the class interval, having the class intervals of equal size, if possible. If this last point is not possible, for example, if the data is heavily skewed, it may require open-ended intervals or intervals of unequal size.

Expressed class limits are those limits bounding a class shown in a frequency diagram. Real class limits are limits  $1/2$  unit above and  $1/2$  unit below the expressed limits. This definition requires a nominal level of measurement.

Class width is defined as the difference between the upper and lower real class limits. A class midpoint is the real lower limit plus  $1/2$  of the class width. (5) (6)

## Coding

Many system of coding have been developed but there is no universal system. Each company has its own specific needs since the development of a classification system is tied to the development of the company database. It is important in the context of this paper to involve statistical concepts and its involvement with developing a coding system. (4)

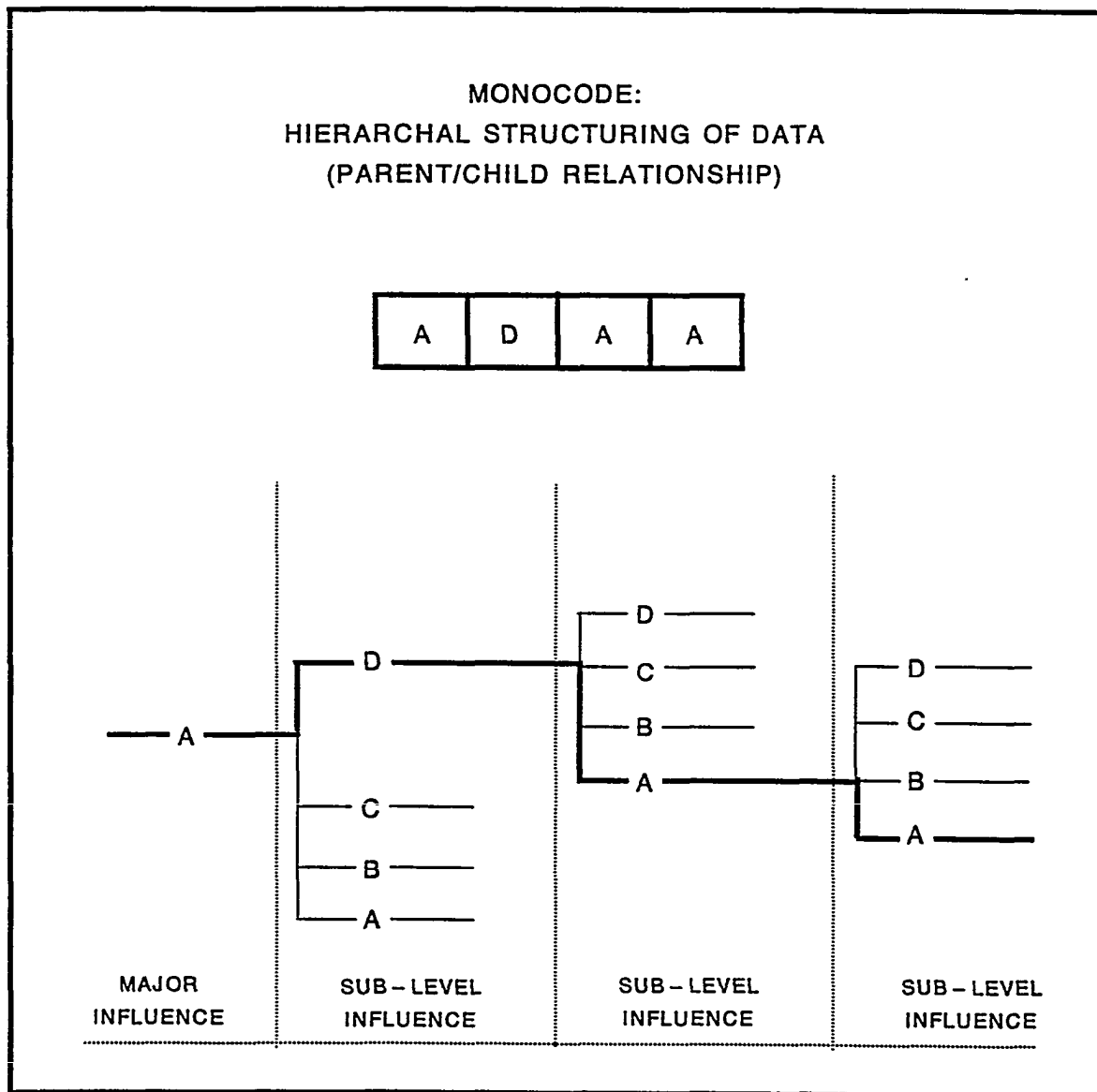
Statistics is based on measurement and part of measurement is having a scale. There are similarities between a scale and a code. Three basic forms of code systems are in common use: hierarchal structure (monocode), fixed-digit-type structure (polycode), and combined structure (multicode). We are not talking about just abbreviations for descriptive terms. We are talking about the structure of data and data relationships. (7)

A scale is a scheme for assigning numbers or symbols to represent characteristics of an element under study. Having a scale or creating a scale is an element required in order to apply statistical methods. (6)

A code is defined as "a system of symbols used in information processing in which numbers or letters or a combination thereof are given a certain meaning."

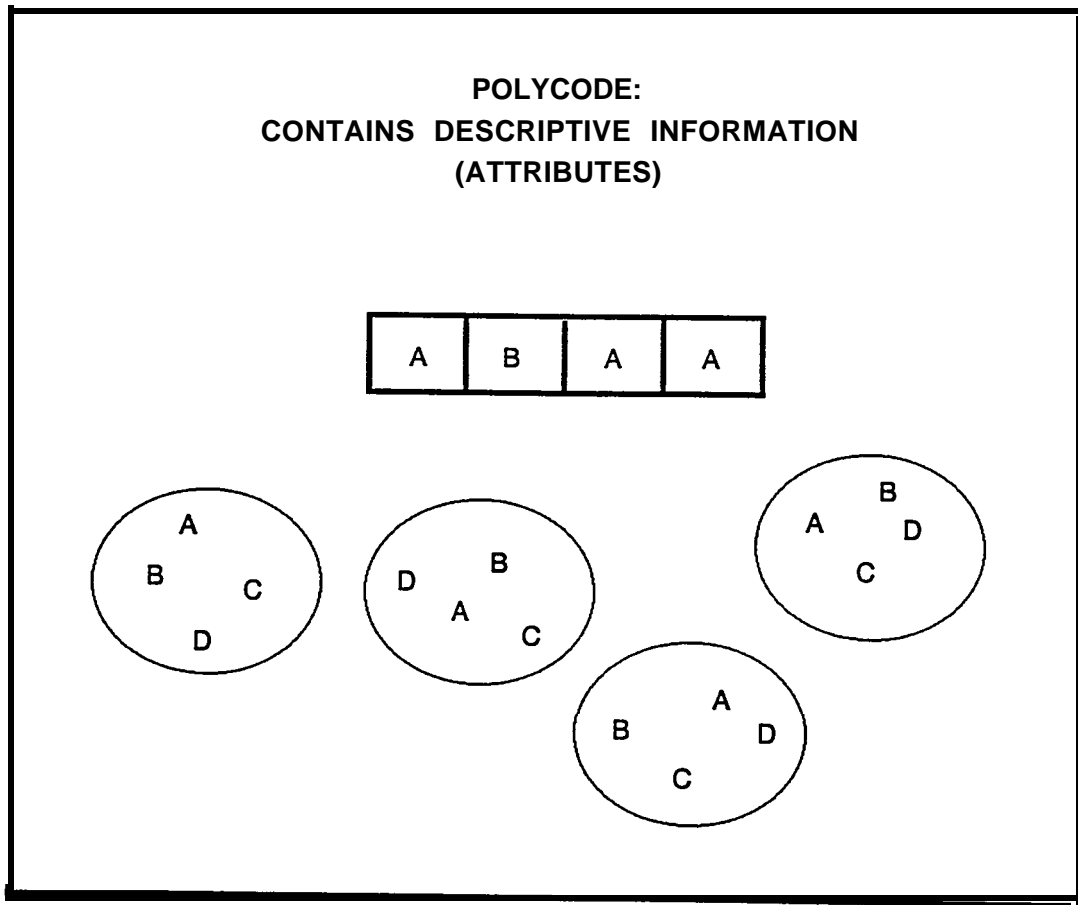
This definition comes from the Industrial Engineer's Handbook. A code is a use of a scale in application to communication needs and computer applications. (4)

A monocode representation is a parent-child structuring of data. That is, an element of the code string corresponds to a sub-level of information, Figure 1.



*FIG. 1: An example of a monocode*

A polycode is a string that contains descriptive information for example, weight, dimensions, and tolerance, Figure 2.

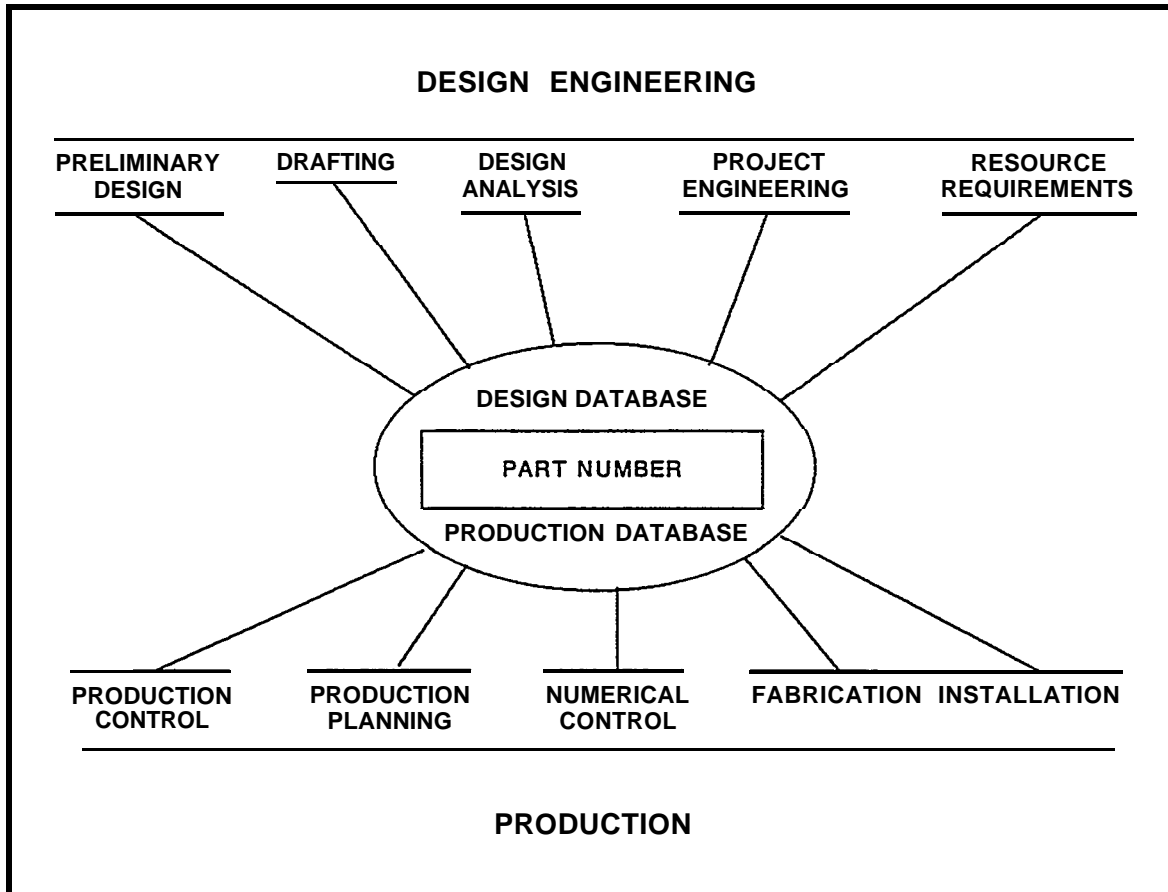


**FIG 2: An example of polycode**

A multicode is a code string that mixes the two types. This, the most common type of code that is arrived at in a final classification and coding scheme. (7)

### Developing a Numbering System

Developing a numbering system is recently of interest in shipbuilding because of advances in computer technology. The increasing power of small computer system and decreasing costs are allowing for decentralized applications. The role of the central computer system is now one of database management. A monocode allows for many combinations of information since it leads through a decision tree. This makes it useful in high-level needs. At operational levels of information, a polycode can be more useful. What evolves is a multicode. In any case, development of a code system is an undertaking that should involve users in all departments affected, Figure 3.



**FIG. 3: illustrates how a part number is used to integrate Production and Engineering functions**

Figure 3 illustrates how a part number is used to integrate Production and Engineering functions.

A code has been defined previously as a symbolic representation of information used in information processing. This is not to say that the only code is for computer applications. A code can be the basic standardization of terms into a language for effective communication within an organization or between organizations. As much benefit can be gained from this concept of a code as from computer applications since a code.

## Statistical Methods

The most effective methods for the creation of a class structure is the use of statistical methods. Other names for the particular processes are cluster analysis (which has been mentioned previously), numerical taxonomy, and classification tree analysis. (1)

Developing a classification system is an stochastic process i.e., a process of performing repeated experiments. It is an iterative process of hypothesis (characterization), coding (defining the class bounds and their representation), classification (collecting data), and analysis (applying an appropriate statistical test). (8)

An experiment in this paper is in the context of statistical meaning. An experiment is used to mean an operation that has several potential outcomes, however, the resulting outcomes are unknown in advance.

An experiment tree is a diagrammatic outline of an experiment and its outcomes. This sort of outline also represents the decision processes in the development and subsequent use of a class structure.

Multi-stage experiments are those that are operated in a succession. (9)

The experiment design should take into account the database design needs. Database design will be discussed below. It is important to note that the hierarchal nature of experiment development is very similar to the decision tree inherent in database functions.

The level of measurement being used determines the types of statistical tests that can be applied. Parametric tests are used at the interval and ratio levels of measurement. Nonparametric tests are used at nominal and ordinal measurement levels. Application of the wrong tests leads to inaccurate conclusions when developing the class structure. (5) (6)

## Database Design Requirements

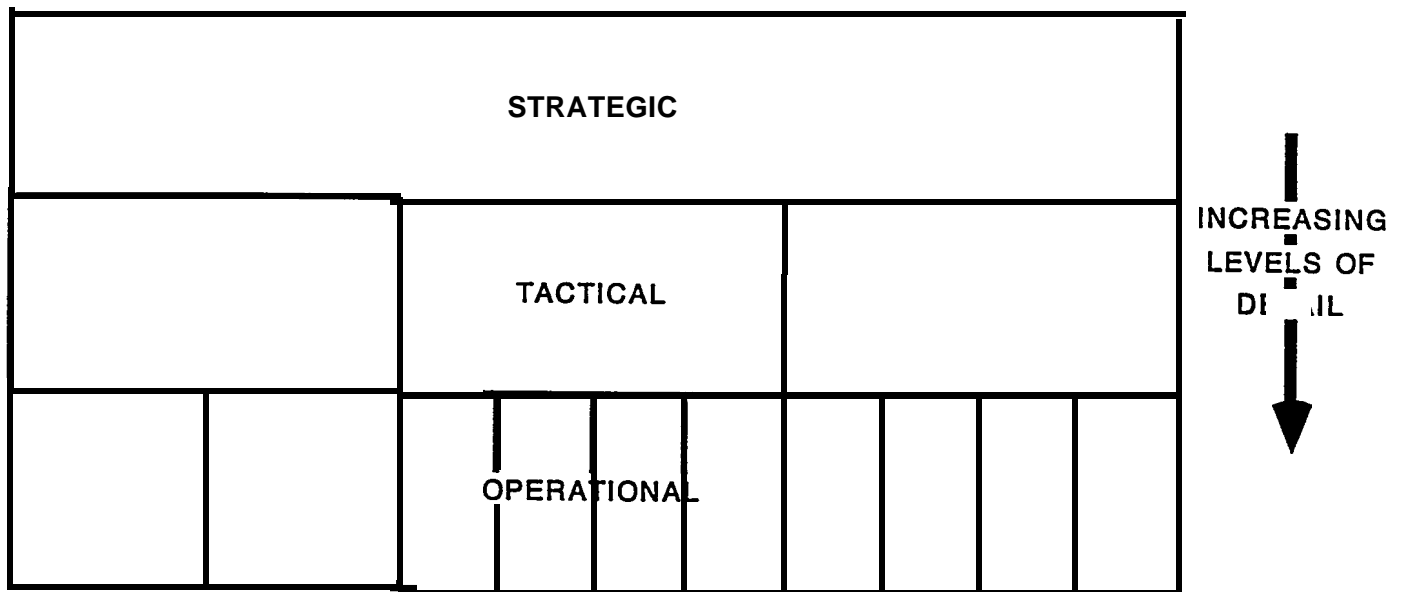
A classification and coding system is a format for storing and retrieving information. Information captured in such a system is manufacturing characteristics, material characteristics, as well as design geometries. The information captured can extend to purchasing, marketing, and customer service characteristics.

In the development of a classification system, the application is to develop a model of the manufacturing process. This model must be able to provide management information on which to make appropriate decisions. It is essential that the classification system meet the needs of all concerned departments in the company, including design/engineering, planning/control, and manufacturing/tooling as well as management. (4)

## Management Information Needs

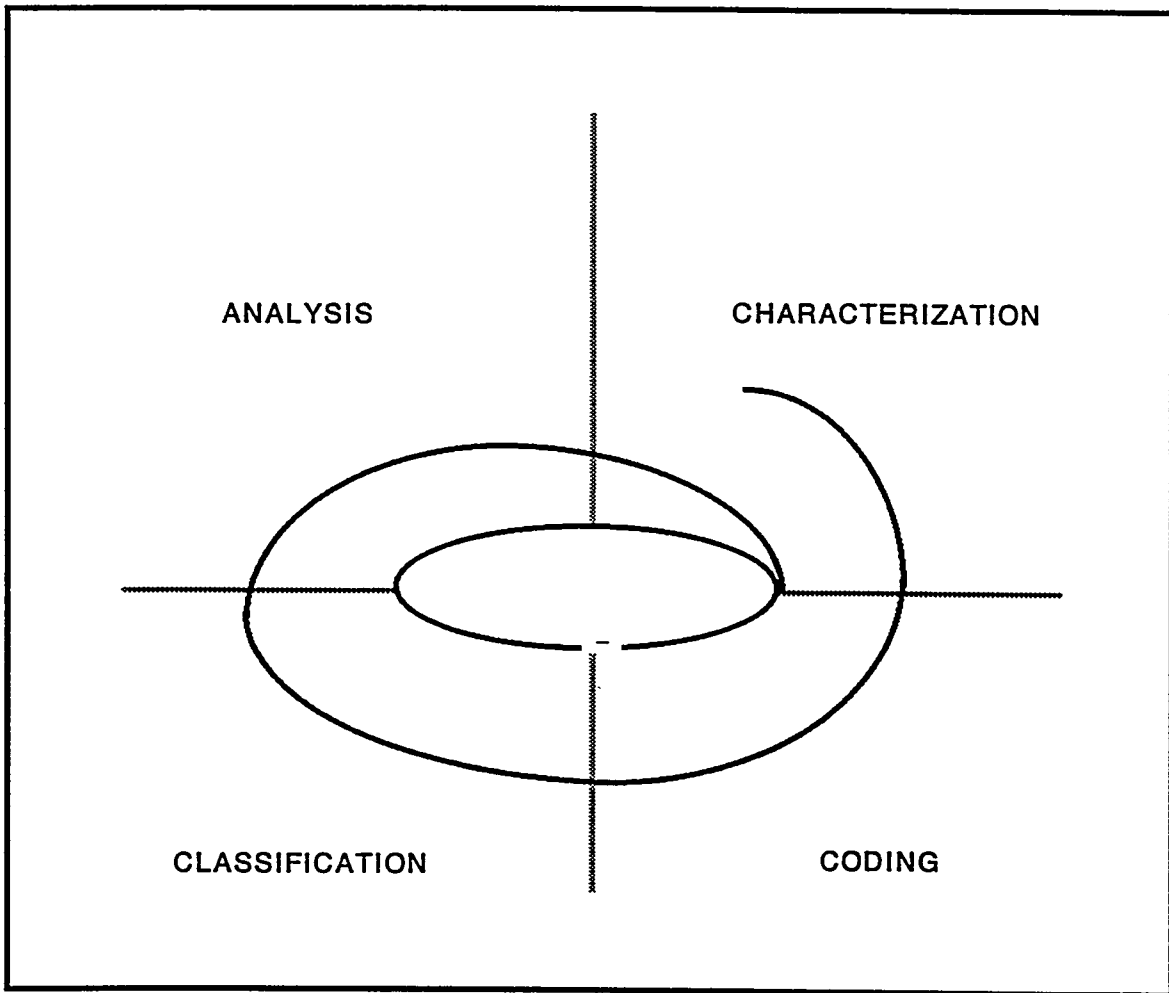
The classification system that is developed must be consistent with the information needs and availability of information at each level of management. In addition to this, the quality of the information is very important.

As the class system is developed, an increasing level of detail is developed consistent with information needs. A top level classification system should support estimating and strategic planning. The next level of class structure should support tactical planning and be of a more detailed nature. That is, more classes may be required to describe material package families, Figure 4.



**FIG. 4** Diagram of top - down class development





*FIG. 5: This diagram illustrates the design spiral through the phases of characterization, coding, classification, and analysis*

An organization is designed around levels of planning, decision making, and control. These are strategic, tactical, and operational levels of management. The time horizons and detail of information required by these levels of management are not the same, but they are related. From strategic to operational is a descending collection of information subsets. Strategic level of management is responsible for long term decision deciding organizational objectives and means for achieving them. The level of information is a summary level. For forecasting the details required for a refined assessment are not available, for example in the development of an estimate for a project bid.

Tactical levels of management are control decisions involving the effective allocation of resources to achieve the goals and objectives of the strategic plan.

Operational levels of decision making involve the specific day-to-day tasks.

### The Process for Developing a Classification System

In the course of our work for the SP-1 panel, we developed a generalized procedure for creating a classification and coding system. Developing a classification and coding system that is universal is very difficult, if not impossible. Each manufacturing operation is different in the way it is organized, operated, and equipped.

The process of developing a classification system is an interactive process. There is a design spiral toward a effective implementation% Figure 5. Further, a class system will constantly evolve as the manufacturing organization and operations change.

#### Characterization

Characterization is the process of identifying a preliminary (hypothesized) set of criteria describing the features of a product.

#### coding

Coding is development of the experiment structure. This is establishing class boundaries and determining an appropriate level of measurement.

#### Classification

This step involves collecting the data and assigning it to the appropriate preliminary class. Assignment of symbolic representation makes data retrieval easier.

#### Analysis

Analysis is the application of a statistical test to determine the validity of the null hypothesis. (8)

#### Step 1: Develop a Hypothesis

The process of developing a classification system begins with the formulation of a hypothesis. This can be the identification of a tree diagram that provides a pattern for multi-stage experiments (illustration). Another approach is to investigate influence factors using multiple regression techniques.

#### Step 2: Determine Influence Factors

Determining the major factors that influence the relationship between process and product is often a matter of experience or familiarity with the product.

Multiple regression models can be developed as a starting point for developing a hierarchical classification structure. The major influence factors can be the top level of the class hierarchy. Lesser influence factors are the sub-levels.

However, experience can serve as a good point from which to begin developing a hypothetical class structure. This is the use of manual/visual method of developing groups.

#### Step 3: Develop the Experiment

Developing an experiment means to create a plan for collecting and analyzing data. This involves identifying the objectives of the experiment, establishing the null hypothesis, and determining the level of measurement that is required.

#### Step 4: Determine Appropriate Statistical Tests

Determining the level of measurement determines the types of tests to be applied. As in any experiment it is necessary to develop an alpha level and a beta level in order to be sure of valid conclusion. Deciding alpha and beta levels also determines the size of the sampling required.

#### Step 5: Collect Data

Collecting the data is the most time consuming process in class development. This is because data presently being collected systematically in most shipyards is not necessarily the data an experiment requires. Easily collected data is not always the right data. This step also requires some ingenuity when data cannot be collected directly.

Collecting data accurately is critical to the validity of the final class structure that is put into place. The wrong data can mislead *the analyst* and cause him to come to the wrong conclusions.

## Step 6: Analyze the Data

Analyzing the results of data collection is the easy part. Many statistical analysis programs are available for microcomputers and programmable calculators. The process does not always require sophisticated techniques. Often simple histograms and scatter plots are sufficient. We have also found that control charts can be very useful in tracking changes in class structure. This can be a problem if a sample is taken during one phase of construction of a ship and inferences are made from only that phase. This problem occurred in our analysis of fabrication of parts for the T-AH contract. We saw a distinct shift in our product mix as construction moved from lower level service spaces into accommodation spaces in the ship.

## Case Studies

Part of our work for this SP-1 project has been to develop a classification and coding system for use in sheetmetal fabrication and installation. As areas for examination we chose a shop application and a shipboard installation application. In both these cases, we addressed real problem and achieved real benefits.

### Case 1: Shop Application

The Metal Outfitting Department at NASSCO is responsible for fabrication and installation of ventilation systems and non-structural steel outfitting items. Our product fabrication mix is diverse and includes ventilation duct, galley case goods, small foundations, and miscellaneous items for other trades in the shipyard. About half of our work in the shop is ventilation, the other half is non-vent products.

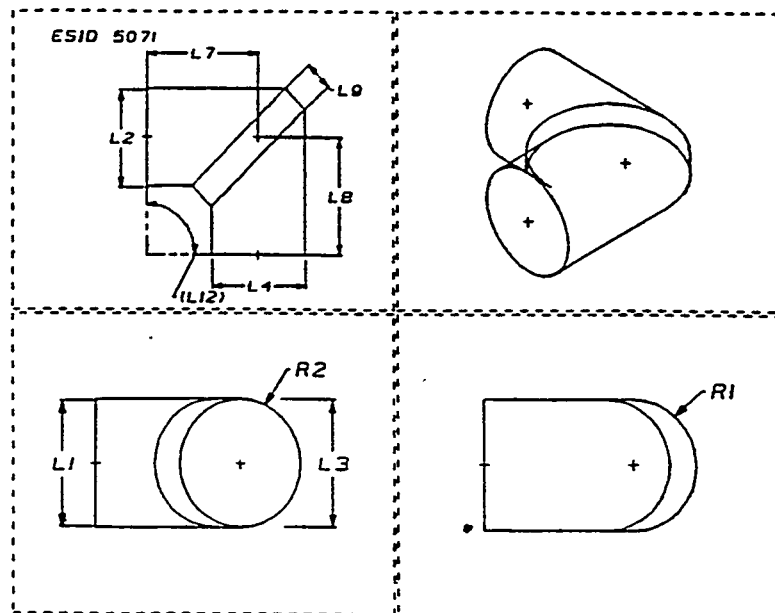
### Vent Part Families

In the non-vent product lines we have clear definitions of type. It would be relatively simple to develop a classification system for these items. We felt that a more instructive process would be to approach the problem of creating vent piece families similar to those in pipe shop cases commonly documented.

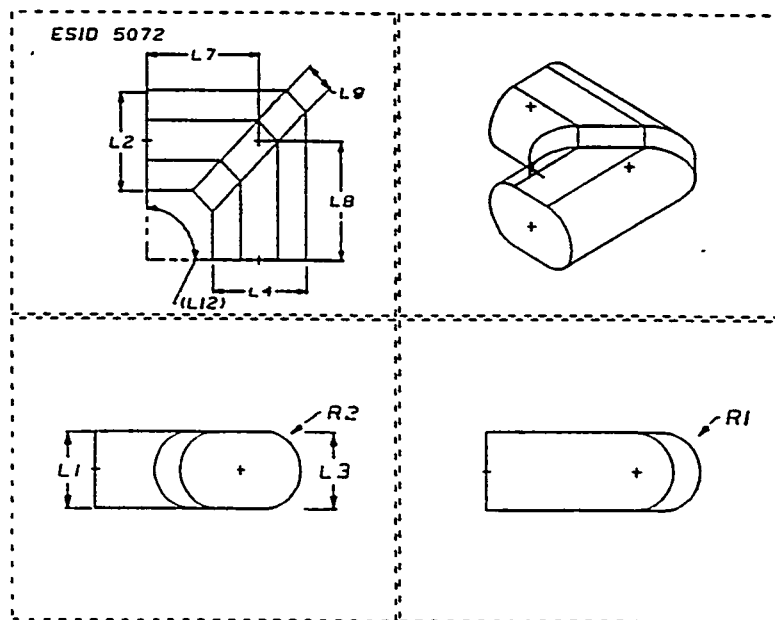
One of the first situations requiring development of a classification was the necessity of finding our shop product mix and the associated work content for each product type. the reason for this need has been to facilitate shop planning and scheduling. If we can identify our product types and the work contents then we can develop capacity and manpower forecasts. This is still in keeping with the concepts of Group Technology. That is, that we are exploiting the relationship between process and product geometry.

A class structure existed in the Metal Outfitting Department at the beginning of this project, Figure 6. This class system was used as baseline part configurations for numerical control applications. Similar classification systems are used in other shipyards. These were

developed using the manual/visual method for developing groups.

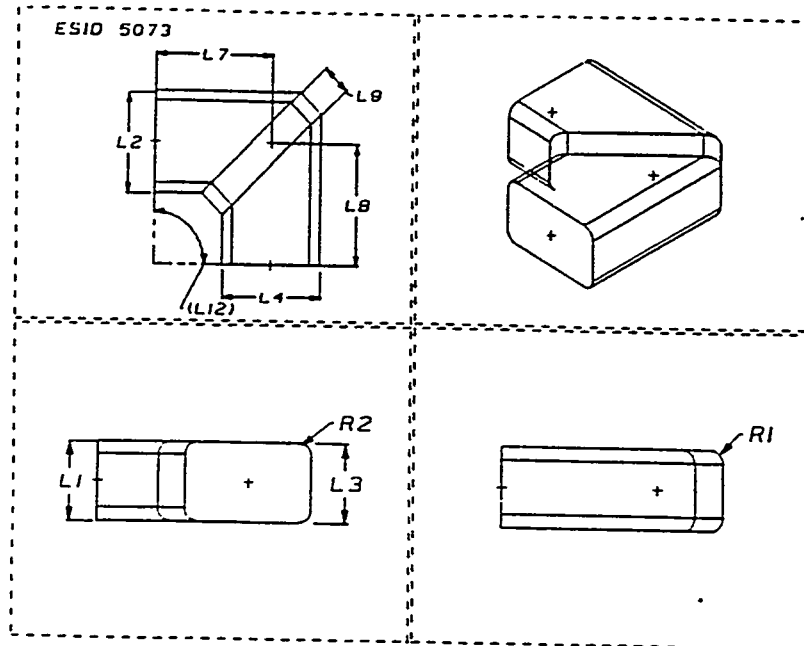


**Round Vaned Turn, ESID 5071**

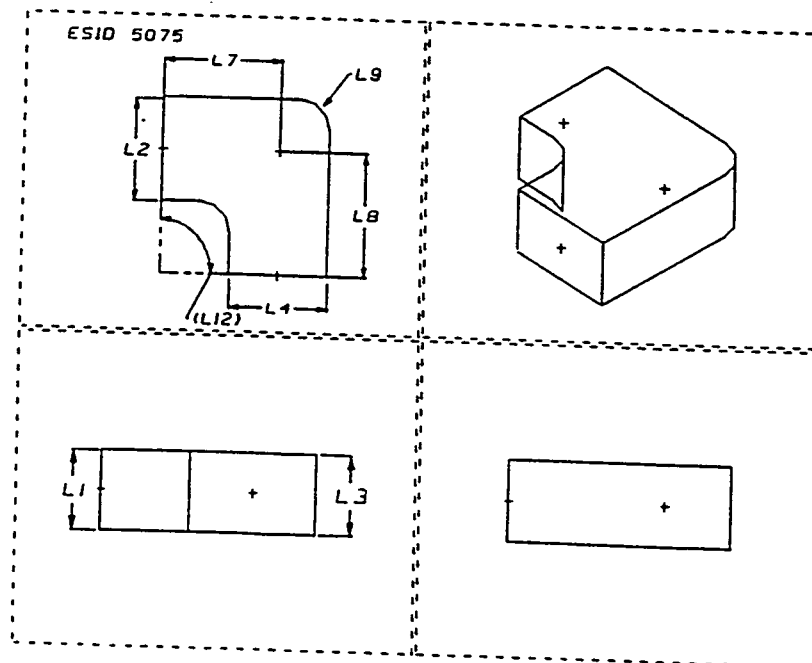


**Flat Oval Vaned Turn, ESID 5072**

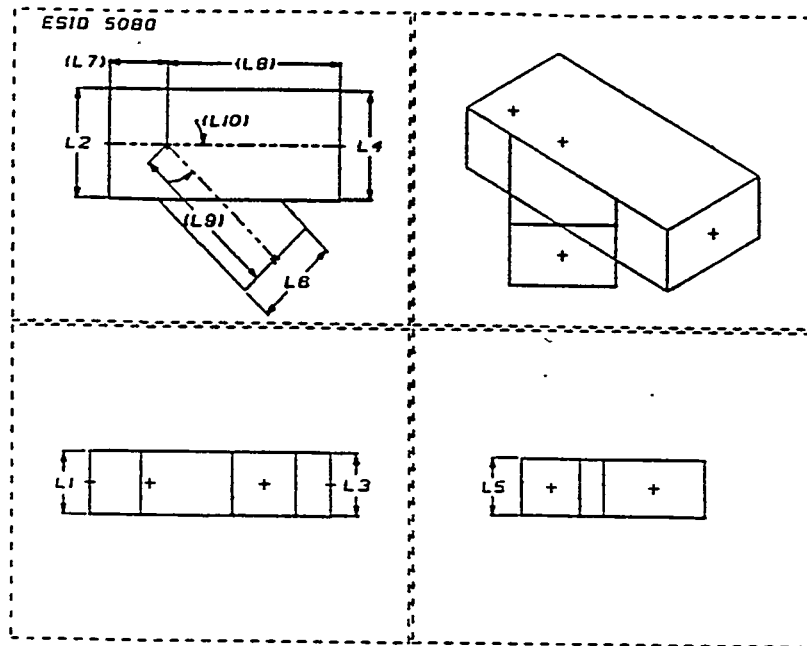
**FIG. 6**



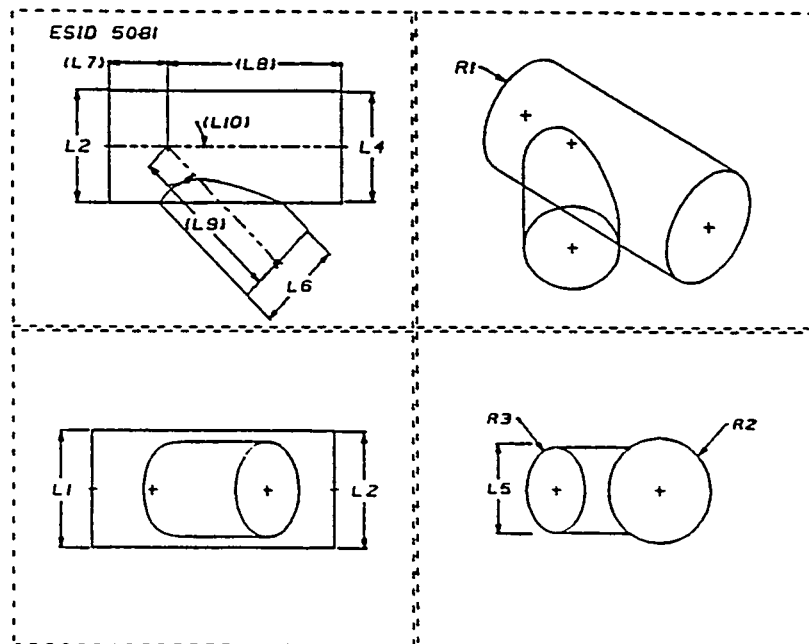
**Radius Corner Vaned Turn, ESID 5073**



**Inlet Elbow, ESID 5075**



**Rectangular Lateral, ESID 5080**



**Round Lateral, ESID 5081**

These shapes were also used when predetermined time standards were developed for the shop under a previous SP-8 project. At the time of this previous project it was considered too complex a task to develop ventilation part families.

Estimating methods in place used the type of material and the quantity of material as parameters. These have proved adequate for strategic prediction of work content. The detailed class structure has been appropriate for operational levels of planning. What was missing was a bridging class structure from the strategic to the operational i.e., we were missing a class structure that supports tactical planning needs.

Our approach was to develop a preliminary hypothesis, set up experiment and collect data according to the class structure in the experiment.

### Develop a Hypothesis

Our first hypothesis was that there might be a stratification of vent pieces by number of detailed shapes. Experience and common sense indicated there was a relationship between the complexity of a piece of vent and its assembly processes. The larger number would require more steps in the assembly process. We also believed that when a vent piece had a large number of shapes that piece of vent was more complex in its configuration.

### Mutually Exclusive and All-inclusive Classes

From our detailed class structure we set up our hypothetical system. Each class was clearly distinct and the set of classes was all-inclusive.

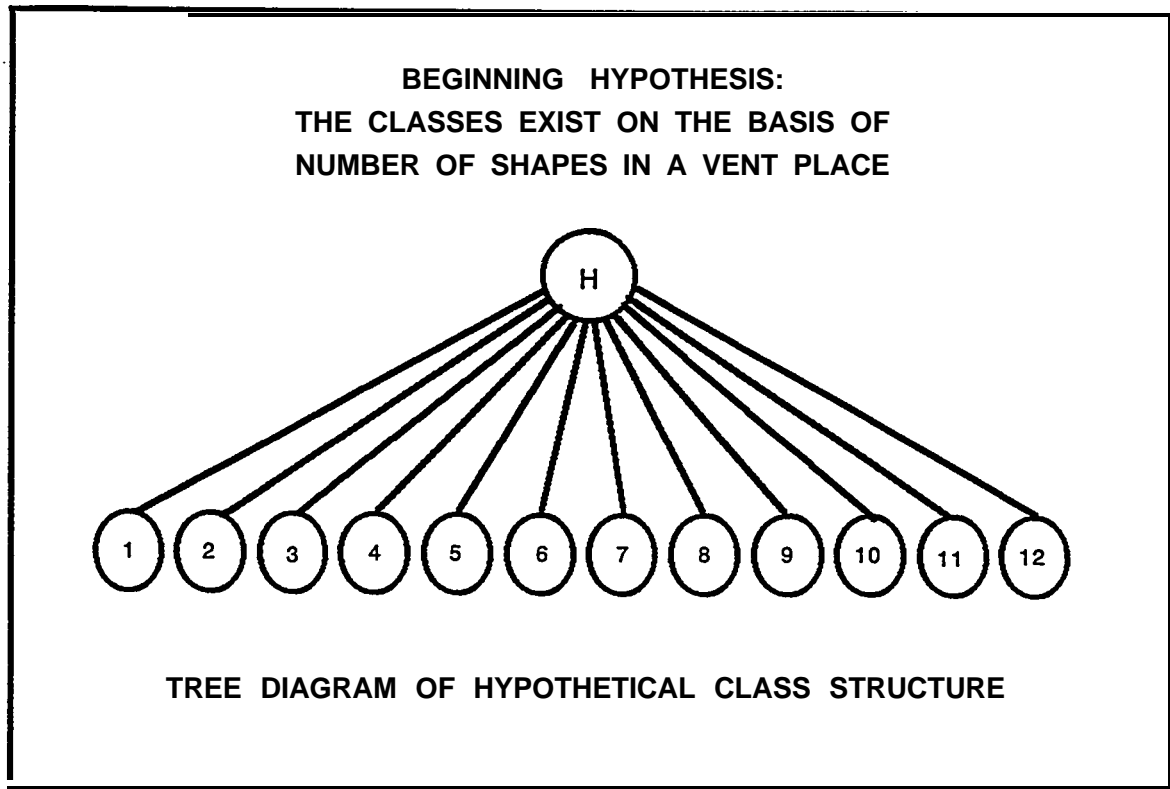
This class structure represents a nominal level of measurement. This allowed application of statistical analysis techniques, in this case the nonparametric Chi squared test was applied.

We began by setting up preliminary class structure, Figure 7. This was our beginning hypothesis. Categories were set up by combinations of configurations. We selected samples of ventilation pieces and examined the frequency of occurrence patterns in the classes. We took a sample of 42 vent sketches and classified them according to the bounds of the preliminary class structure. Figure 8 shows the resulting frequency distribution.

The histogram shows the distribution of our sample. Consistent with statistical requirements for a class structure with smoothed distribution as well as possible. We collapsed the original classes into seven then finally into three classes, Figure 9.

Boundaries for the smoothed classes were determined to be 1 shape, 2 to 4 shapes, 5 to 12 shapes, and 12 shapes above, Figure 10. This last class was to make the system open ended and, therefore, all-inclusive. We gave these classes names (which amounts to coding): simple, typical, and complex respectively.





**FIG. 7: Experiment tree diagram**

We looked for a way of validating our developed class structure that would indicate a process correlation to the classes. We collected time against samples from each class.

#### Analyzed Distribution

A plot of distributions for work content by class is shown below, Figure 11. Statistical testing showed that there was a good chance that these are distinct classes. However, the degree of overlap in the distribution indicates some ambiguity in the class boundaries. Results of statistical analysis applied to these data showed the potential significance of the class structure having process distinctions.

#### Unexplained Variance

When we began to apply the class structure developed, we found the central tendency of our returns to be centered. However, we identified variances that were not accounted for by the class scheme.

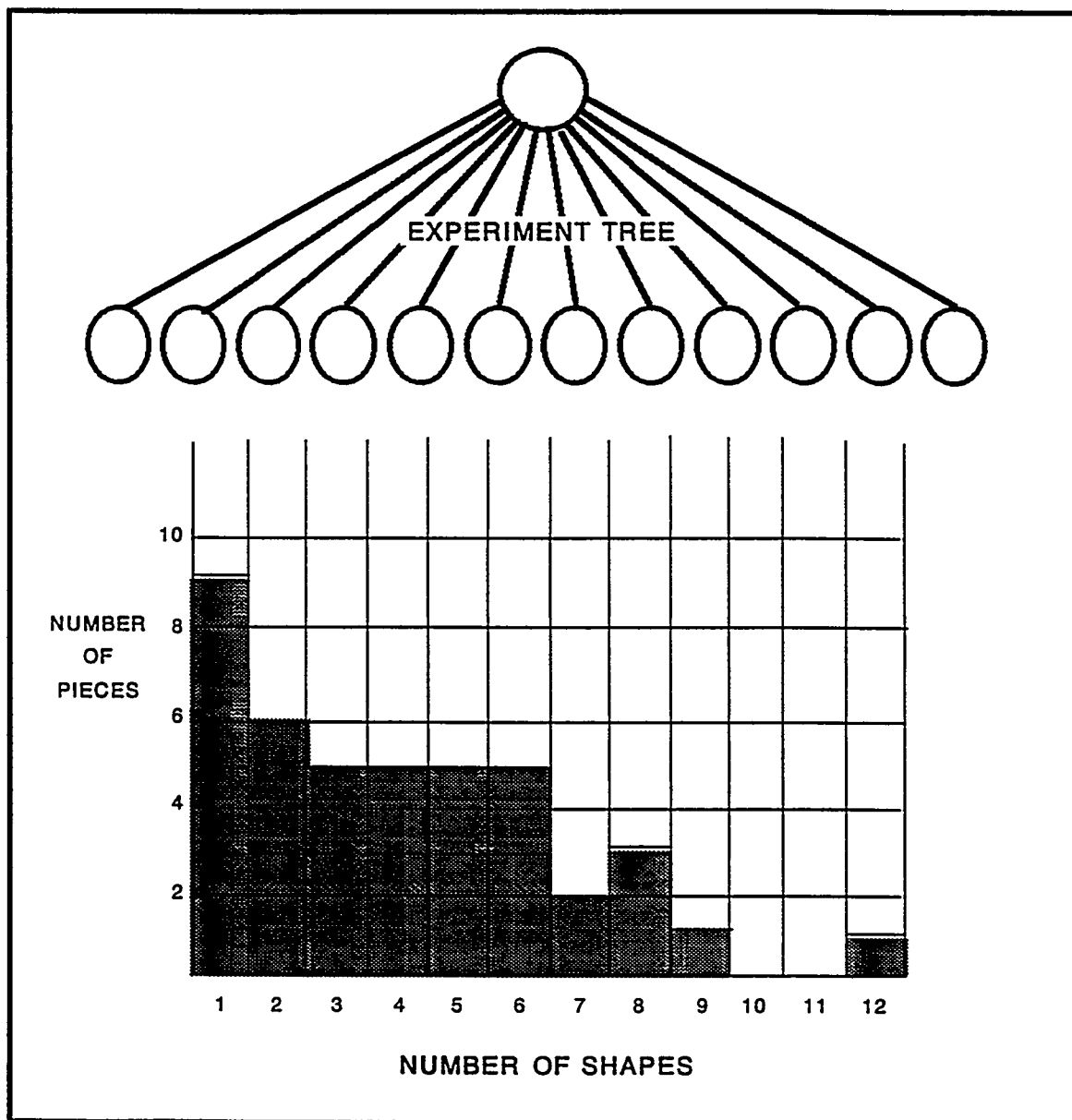


FIG. 8: Frequency Distribution

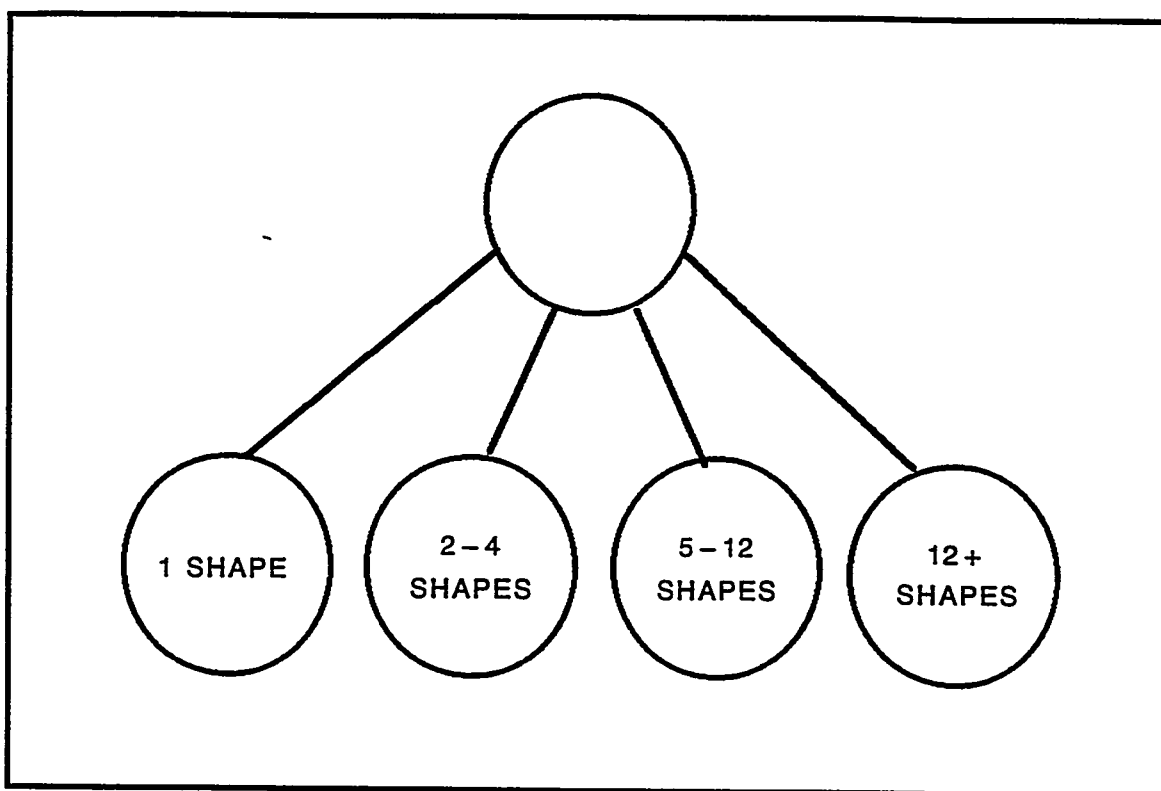


FIG. 9: Smoothed vent shape class experiment

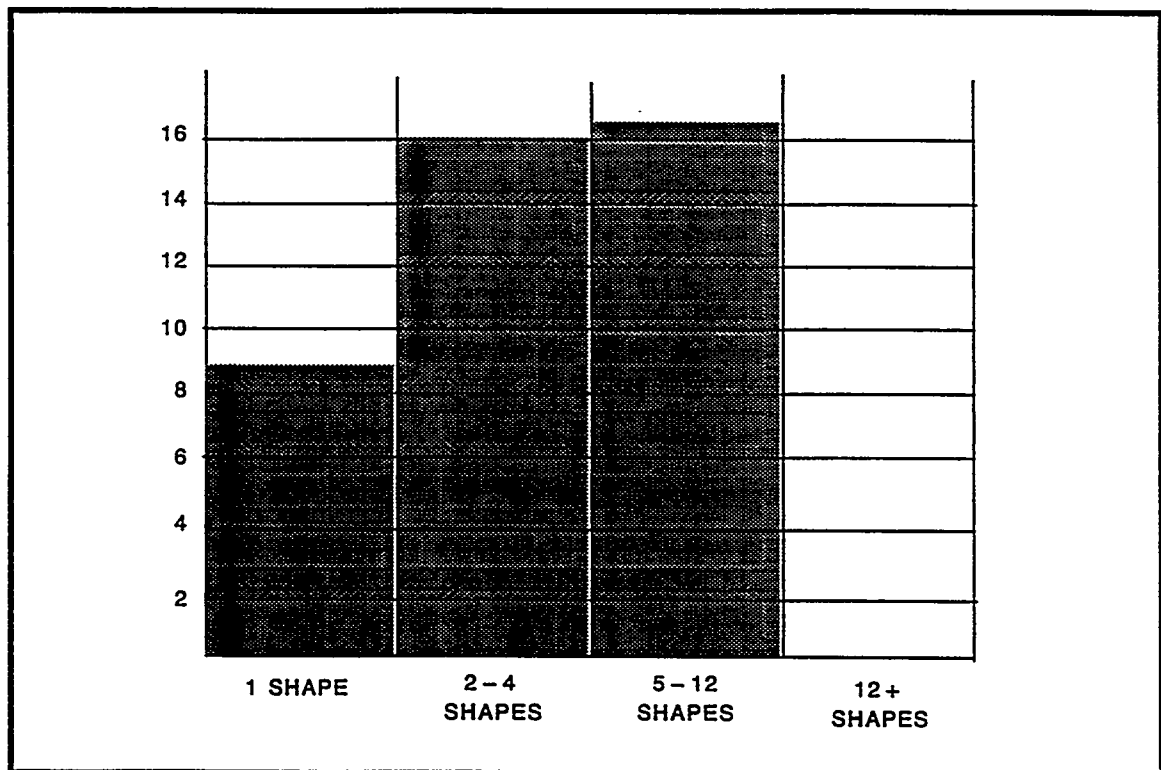


FIG. 10: Vent shape frequency distribution for smoothed class volume

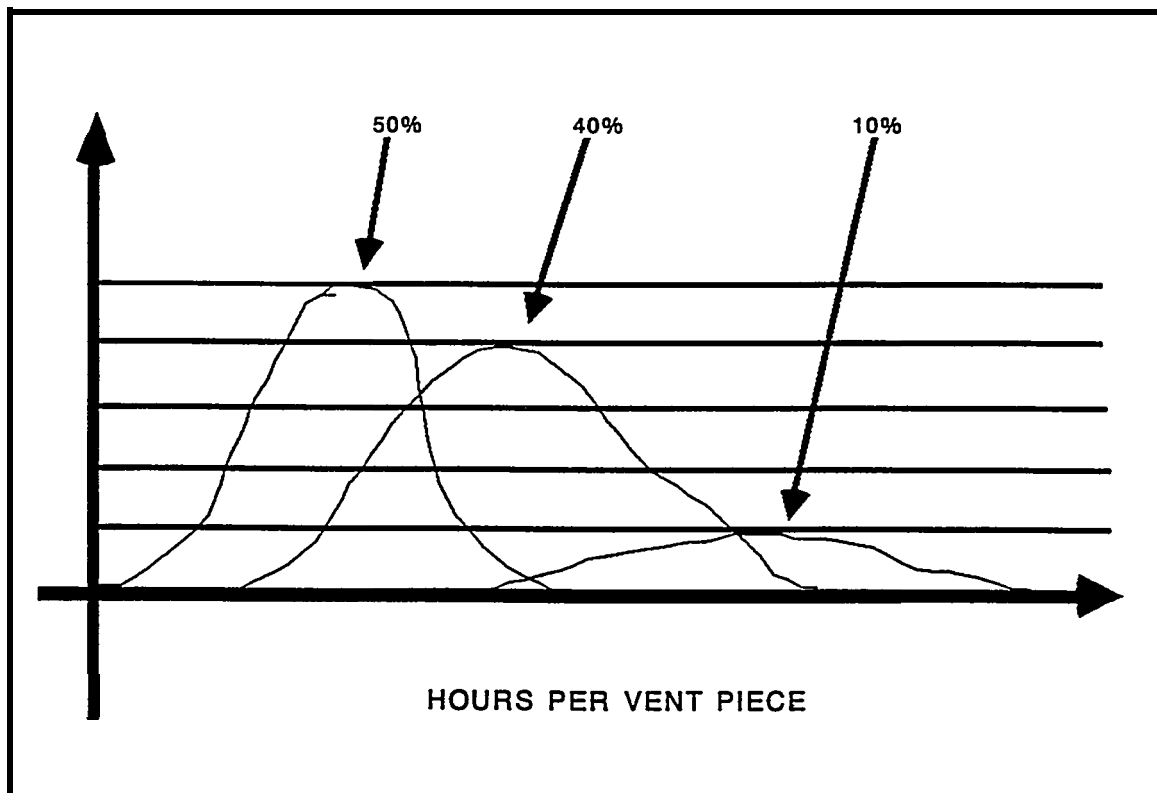
A process analysis was then performed against each class type. Comparison of the processes against the class type showed no difference in the process sequence. From this information we hypothesized that the difference between each class type was probably from another factor related to handling, most likely weight.

We considered another characteristics that would also bridge the strategic level of class with the operational class structure. We proposed that material type was an unaccounted influence on the work processes. This was in place to some extent in the estimating process.

Incorporating material type from the strategic level of classification might take into account the variance. This requirement was not readily apparent in the process analysis since two vent pieces of the same configuration but different materials would differ basically in the handling time.

#### Developed Class Structure

Our present class structure is in the illustration, Figure 12. Top level is material type, heavy (10 gauge and above) and light (below 10 gauge). The next level is our class structure of simple (1 shape), typical (2 to 4 shapes), and complex (5 to 12 shapes), and other (more than 12 shapes), Figure 13. At the lowest level are the combinations of our shape types. (8)



**FIG. 11: Work content distribution**

## Case 2: Installation Application

In this second case study, we will be looking at our approach to developing a class scheme for onboard steel outfitting. We are still in the process of developing this scheme and have not yet found a good class structure. Several reasons for this will be discussed below.

HEAVY				LIGHT			
simple	typical	complex	other	simple	typical	complex	other

Fig. 12 Final vent class scheme

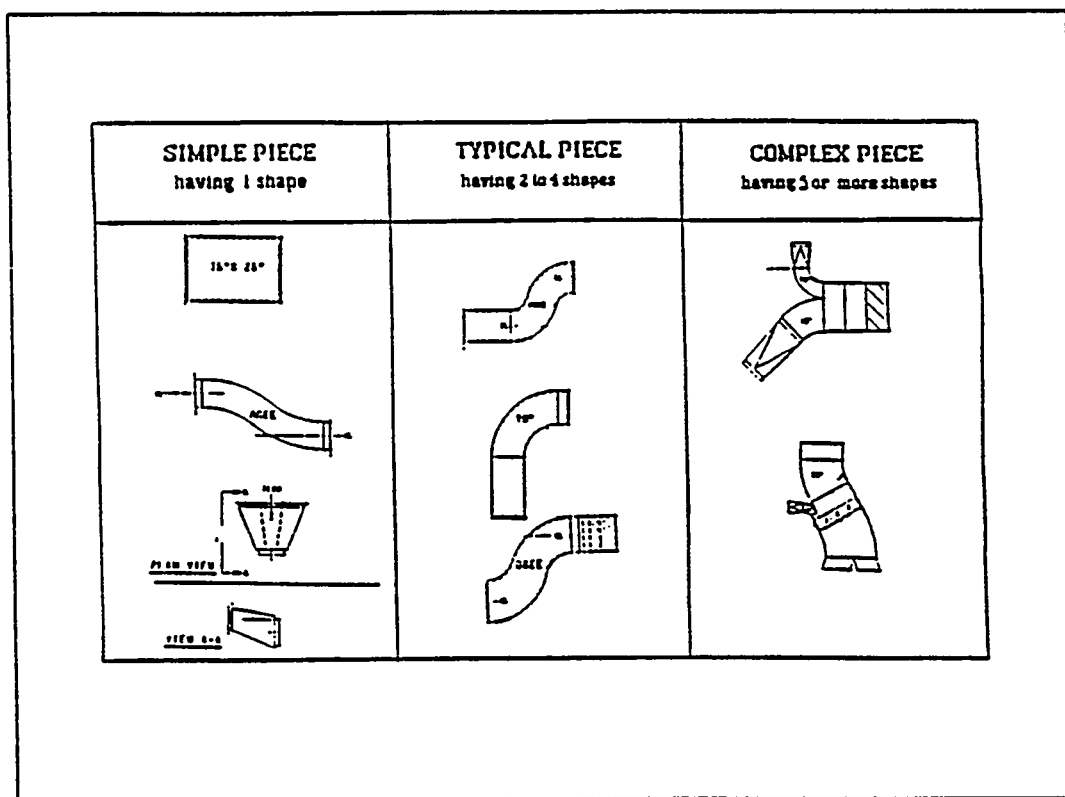


Fig. 13

## Steel Outfitting Class Structure

Applications of Group Technology have traditionally been shop oriented. Shop processes are controlled and predictable, whereas, installation processes are less so. Classification and coding also can be used to develop and exploit the commonality in installation operations. The steps in approaching the problem are the same as for the shop application: hypothesis, develop an experiment, collect data, and test for significance.

## Reorganization of Responsibility

In November of 1985, the Sheetmetal Department at NASSCO absorbed the responsibilities for Steel Outfitting. This presented some unique problems. Until this move, management had little visibility on steel outfitting operations. The volume of this type of work was small relative to work of the parent hull organization. consequently, its management information was swallowed up in the variances of the parent organization. Since it was of lesser significance, little attention was paid to the planning functions necessary to make this type of work run smoothly. This is not to say that Steel Outfitting did not represent a large amount of work. In fact, the combination of the two departments doubled the side of the Metal Outfitting Department's responsibilities.

Because of this change, we have had to develop the management information philosophy to support strategic, tactical and operational planning for Steel Outfitting. In effect, we have started from scratch building a new descriptive scheme for steel outfitting items where one has not existed before. This situation has provided an opportunity to confirm our methods for developing a classification and coding system.

At the strategic level of management information we have had to find a class structure that can be used to predict our long range work loads. This information is required to support budgeting and scheduling tasks on a six month to one year time horizon. Information about material type is very general and consequently limited. At the tactical level, the class structure must support the same tasks, but at a shorter, two month, time horizon. Information about material type at this point is more detailed. Finally, at the operational level, we have the need to identify specific work processes.

## Strategic

Developing strategic information resources requires forming a hypothesis about general material characteristics that have an influence on the nature of the work processes. We have started applying classification and coding system methods to accomplish this. In collection of data we have used packages of material rather than more detailed part explosions.

## Multiple Regression Model

In developing a strategic classification structure we have begun to create a multiple regression model of factors that influence work content. Multiple regression is similar to simple regression except that it uses more than one independent variable. We collected characteristics of packages, among these were weight, number of connections to be fit-up, and lineal dimensions. Our regression model was developed using the forward selection process in which hypothesized factors are added step-wise to the regression formula. As more factors are introduced, the correlation of the regression model becomes better.

## Developing Experiments

The regression model has given an indication of major influence factors. These are:

- 1) The number of connections requiring fit-up
- 2) The weight of the package
- 3) The lineal footage of the package.

What we have attempted to do is find correlating class groupings of these characteristics. Our first hypothesized class scheme involved using commonly occurring descriptive terms for these packages. We then wanted to find distinctive groupings of these characteristics.

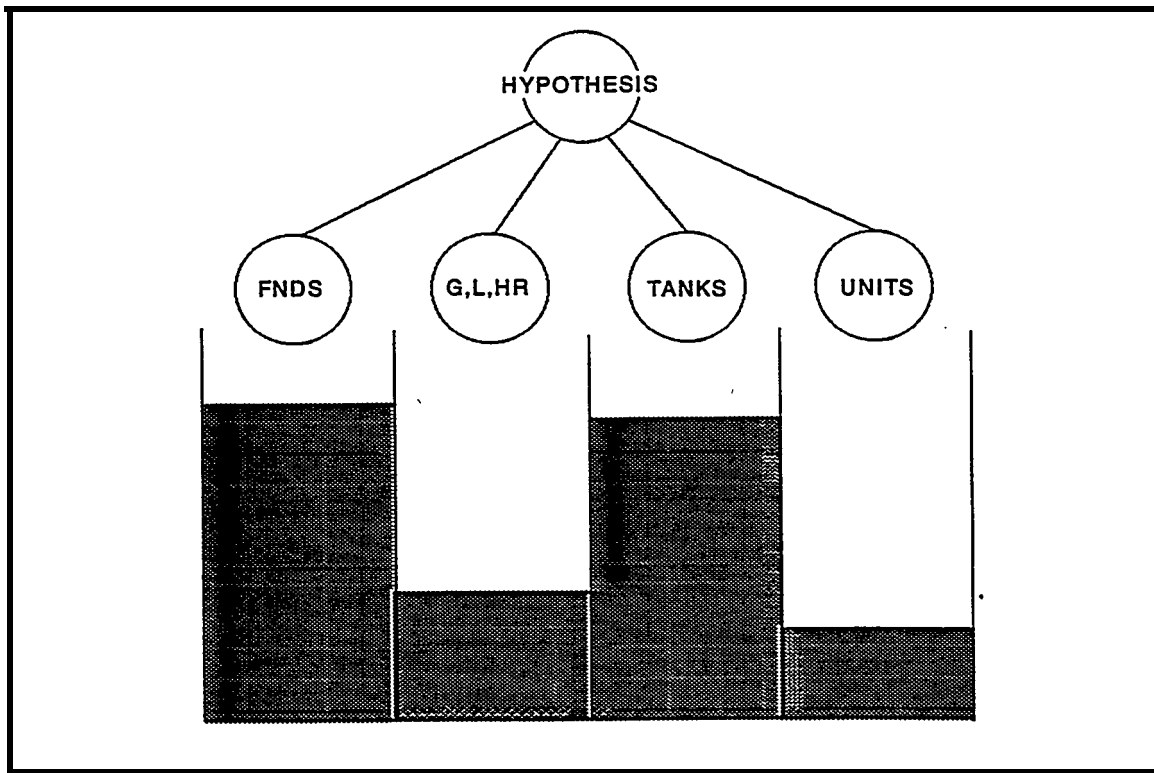
The preliminary classification structure we have set up has four major categories:

- . Foundation package
- . Grating, ladders and handrail package
- . Unit package
- . Tank package.

These major classes may not be all-inclusive so we have also created an open-internal class of "other", Figure 14. What we have yet to do is tie these preliminary class codes to groupings in numbers of fit-up connections. We have not yet been able to show this relationship by statistical criteria.

## Tactical

In the development of tactical information we are using classification and coding to create a scheme of package descriptions by sub-major influencing characteristics. This is a more detailed classification scheme and must be consistent with the strategic classification scheme.



**FIG. 14: Steel outfitting experiment tree and relative frequency of occurrence**

We have found the weight of a package to be a significant influence on the work content of the package. This makes sense because the heavier the package the more time required to handle the parts, either because there are more of them or because they are larger. The next level of descriptive classification is as to what type of foundation are we installing. Major types are hypothesized as pump, machinery, or electrical. Sub-level class structures have also been hypothesized for the other strategic level classes. In these cases, what we again have to be able to show is a definite grouping of weights to correspond to these classes. If we can find groupings, then we have defined class boundaries for a characteristic that has influence on work content. Again, we have yet to show this relationship exists.

### Operational

At the operational information level, we are using process analysis rather than classification and coding to form systematic descriptions of onboard work operations and their associated material requirements. We have chosen this method because it will allow us to standardize and simplify our installation procedures. This benefit will be of immediate use to our department where the strategic and tactical information will be of benefit on another contract.



FOUNDATION			LADDERS, GRATINGS, AND HANDRAILS	TANKS			UNIT			OTHER
PUMP	MACHINERY	ELECTRICAL		AIR	OIL	WATER	STRUCTURAL	PIPING	MACHINERY	

**FIG. 15: Steel outfitting class scheme**

## Problems

In the above discussions, we have said that we have not been able to verify the statistical significance of these class structures. This is not because of a failure in our approach, but from the poor quality of data we have relied on. The problems we are encountering have to do with using the company's labor management system. The returns from this system are contaminated by schedule adherence problems, rework and changes in labor charging philosophies.

## Conclusions and Recommendations

In this paper we have approached the process of developing a classification and coding system from a data base design standpoint. The tools for creating a useful scheme are basic statistical definitions and methods. This is in contrast to other discussions which deal largely with the benefits of such scheme without touching on the methodology for creating such systems.

Things that we have learned on the way are:

- 1) Determine the influence factors
- 2) Develop an experimental approach
- 3) Collect-accurate data.

A suggestion for others applying classification and coding methods are to use

microcomputer resources. Data base software and statistical packages can make the analysis job quick and accurate.

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**FINAL REPORT**  
**FOR**  
**GROUP TECHNOLOGY/FLOW APPLICATION**  
**IN PRODUCTION SHOPS**

**TO**

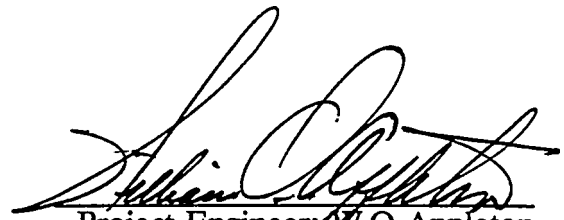
**SNAME/SHIP PRODUCTION**  
**PANEL SP-1 FACILITIES**

**MAY 14, 1986**

**SUB-PROJECT**  
**CELLULAR APPROACH TO**  
**VALVE REPAIR**

**BY**

**NATIONAL STEEL AND SHIPBUILDING COMPANY**  
**HARBOR DRIVE AND 28TH STREET**  
**SAN DIEGO, CA 92138**



Project Engineer: W.O. Appleton

## **GROUP TECHNOLOGY/FLOW APPLICATION IN PRODUCTION SHOPS: CELLULAR APPROACH TO VALVE REPAIR**

**INTRODUCTION:** There are many definitions of Group Technology in use today. Ten Engineers involved with this work will probably give ten different definitions. There is a reason for this and that is the depth and breadth of GT applications, which, incidentally, have not been exhausted.

One definition used by Susan O. Schall in an IE news article seems to capture the meaning and implications quite well: "Group Technology is a technique which identifies and brings together related or similar components and uses their similarities to improve the economies of production."

The cell or cellular approach is a basic component of Group Technology and no study of GT applications seems complete without such a sub-project.

NASSCO, like many shipyards, has a large commitment to ship repair and as such dedicates shop facilities, equipment, and organization to repair support work. At NASSCO, the primary shop for repair is called the Inside Repair Shop which is integrated with the machine shop and organized as two shop entities under one production manager and staff.

It is the IR shop in which our studies took place and to which the results are directed.

This study was preceded by several discussions with the shop management in order to have a clear understanding of why this repair function was selected over others, what Group Technology was and how it would relate to department improvement, and how the Engineering study would be conducted. It was found, in this case, that examples of previously completed Group Technology applications provided the clearest understanding of the "before and after" effect.

A member of the shop staff joined the project effort and became involved in all phases of the study as a source of detailed information, a screen for ideas, and participant in the resulting planning. Where an organization can free a staff member who can be trained in Group Technology, such a person can become the Project Engineer.

**BACKGROUND**: The IR shop at NASSCO has been in existence for many years and as in most yards has had high and low cycles of business activity based on the needs of repair contracts, as well as the availability of work. This has always caused fluctuation in labor force which results in a continual change-over of individual workers in what tends to be a rather skilled area. Therefore, while standard QA procedures and specifications control the repair, the work method and procedure vary widely depending on the individual worker.

The same conditions also influence the layout, flow and utilization of the shop space with the result that flexibility must be maintained, even to the extent that a specific plan of operation and flows only lasts through the applicable contract.

Valves are synonymous with ships and represent a large repair requirement with wide variations in types and sizes. The production operations are varied and supporting activities such as stores, inspection, in-process storage, and test are involved.

In summary, these conditions make this an excellent and challenging subject for a GT study:

1. A skilled labor force change-over of 40%-50%.
2. Shop space utilization requiring a maximum in flexibility.
3. A product with a common genus but varying from type to type and size to size.

Sometimes there is a tendency to see Group Technology as requiring great degrees of similarity as a justification for initiating a study. This can be detrimental to the opportunity for success. A minimum study is highly recommended in order to properly evaluate the nature of both similarities and dissimilarities. The former will define the nature of the cell while the latter helps to define everything from a separate cell to a sub-cell to an "outside the cell" operation. Group Technology application is so far-reaching that study data should not be seen as positives and negatives but rather as similarities and dissimilarities, each to be evaluated, each to be weighted.

**PROJECT STUDIES**: We studied the valve repair activity, utilizing the flow process analysis technique. The Engineer compiled processing, handling and storing data and made elemental comparisons despite the wide variation in valve type and size.

The flow process method has been around for some time (Figure 1). It is graphic, through use of the symbols and entry of time values in the applicable column, and can be analyzed directly without additional recap. Where very close time values are sought, conventional time study forms might serve the purpose.

FLOW PROCESS CHART							
SUBJECT <u>GLOBE VALVE REPAIR</u>			DATE <u>08-07-85</u>				
CHART BEGINS <u>VALVE BROUGHT FROM SHIP</u>							
CHART ENDS <u>VALVE TAKEN TO SHIP</u>							
SYMBOLS	DESCRIPTION	REF	DISTANCE MOVED IN FEET	UNIT OPER TIME IN HOURS	UNIT TRANS TIME IN HOURS	DELAY TIME IN HOURS	STORAGE TIME IN HOURS
○➡▷□▽	Forklift valves to I-R Shop		141				
●➡▷▷□▽	Disassembly			1			
○➡▷▷□▽	Transport to Sandblast		182				
●➡▷▷□▽	Sandblast			0.75			
○➡▷▷□▽	Transport to Inspection		159				
○➡▷▷■▽	Inspected			0.08			
○➡▷▷□▽	Transport to Storage		67				
○➡▷▷□▽	Store			3 Weeks			
○➡▷▷□▽	Transport to Work Bench		59				
○➡▷▷□▽	Search for aluminum to make lapping plate		120	0.25			
●➡▷▷□▽	Cut aluminum to needed dimensions			0.33			
●➡▷▷□▽	Machine aluminum			1.3			
●➡▷▷□▽	Lap valve			3.2			
●➡▷▷□▽	Assemble			0.25			
○➡▷▷□▽	Transport to hydrotest		110				
●➡▷▷□▽	Hydrotest			0.2			
○➡▷▷□▽	Forklift to ship						
○➡▷▷□▽							
○➡▷▷□▽							

FIG. 1

Cellular related Group Technology studies should emphasize distance of travel for both man and material. Review and improve these (if indicated) as a first priority in the plan.

The main types of valves are butterfly, globe and gate varying in size from 3" to over 30". Similarities and dissimilarities are of equal importance in early evaluation since, for example: (1) various type valves require lapping (similar), but the lapping techniques were totally different (dissimilar): (2) Valve testing is common to all valves (similar), but test jigging varies widely between types (dissimilar). The character of the cell therefore dictates accommodation to a common "family" with certain sharp variations in specific requirements.

For clarity of reference and planning, flow charts showing typical flow for each type valve and a general flow of the family of valves are shown in Figures 1A 1B, 1C, and 1D.

The typical flow captures the high degree of similarities for the three general valve types while the detailed flow charts deal with the different detailed operations required.

Dissimilarities sometimes require only different tooling but may require a different work station design or even an additional flow lane.

Make a test with this key question "Does the dissimilarity fit within the cell?"

The best and most operable cells often contain dissimilar operations and functions.

These studies and analyses further identify operations being performed outside of the immediate area, which should be included within a cellular flow concept, as well as material movements and handling which could be reduced by cellular design. A planned view flow is shown in Figure 2.

Things do not appear too badly given the variables of the Repair Business as we stated previously. However, the long distance to the Sand Blast and In-process Storage, and the process flow pattern stand out. A summary of the objectives stress the solution to these problems:

- (1) Reduce travel distances.
- (2) Smooth the in-process flow.
- (3) Increase the in-process storage capacity through space utilization and closer proximity to the work station(s).
- (4) Improve repair methods.



# TYPICAL VALVE

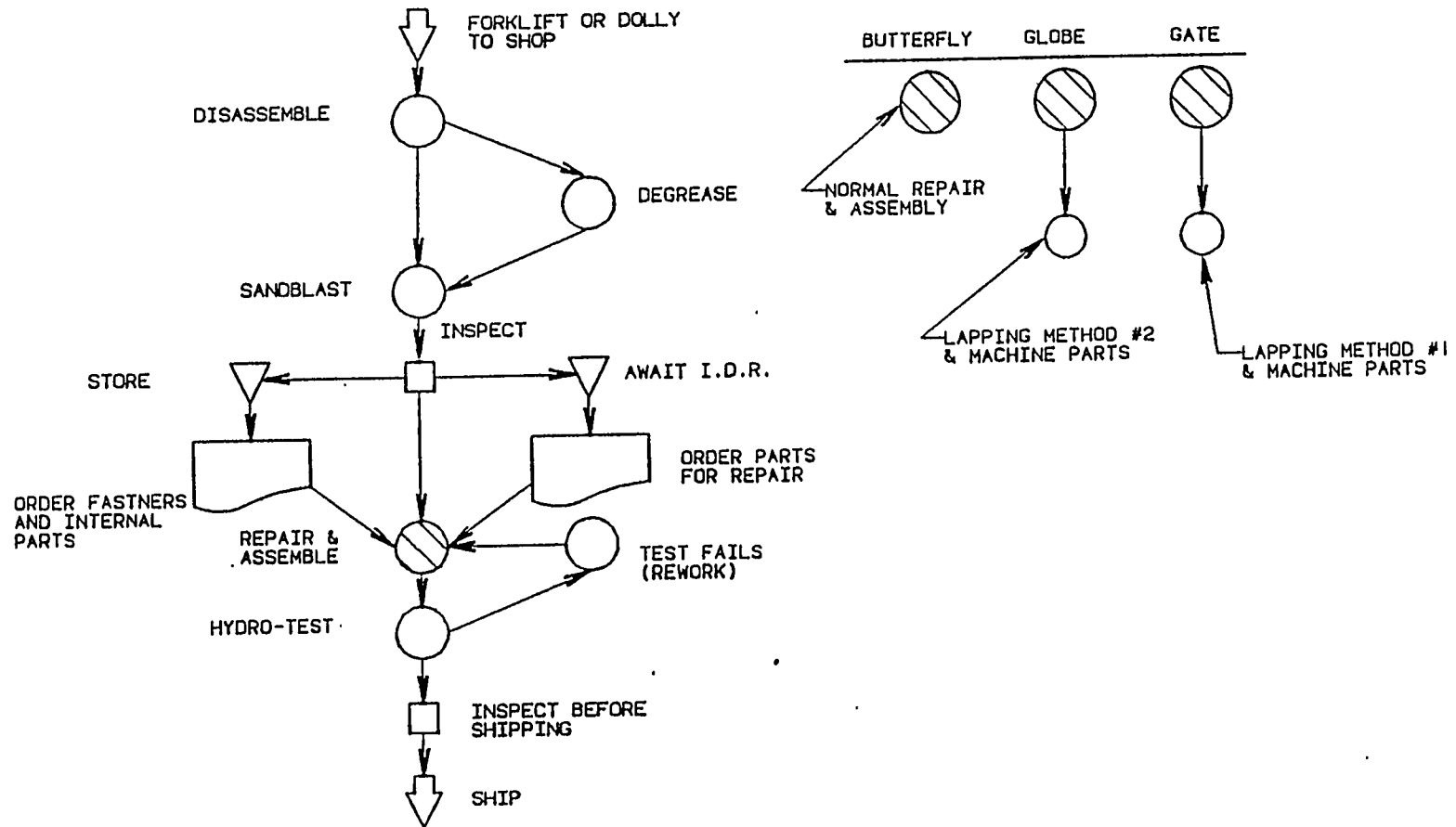


FIG. 1A

## FLOW CHART FOR THE REPAIR OF BUTTERFLY VALVES

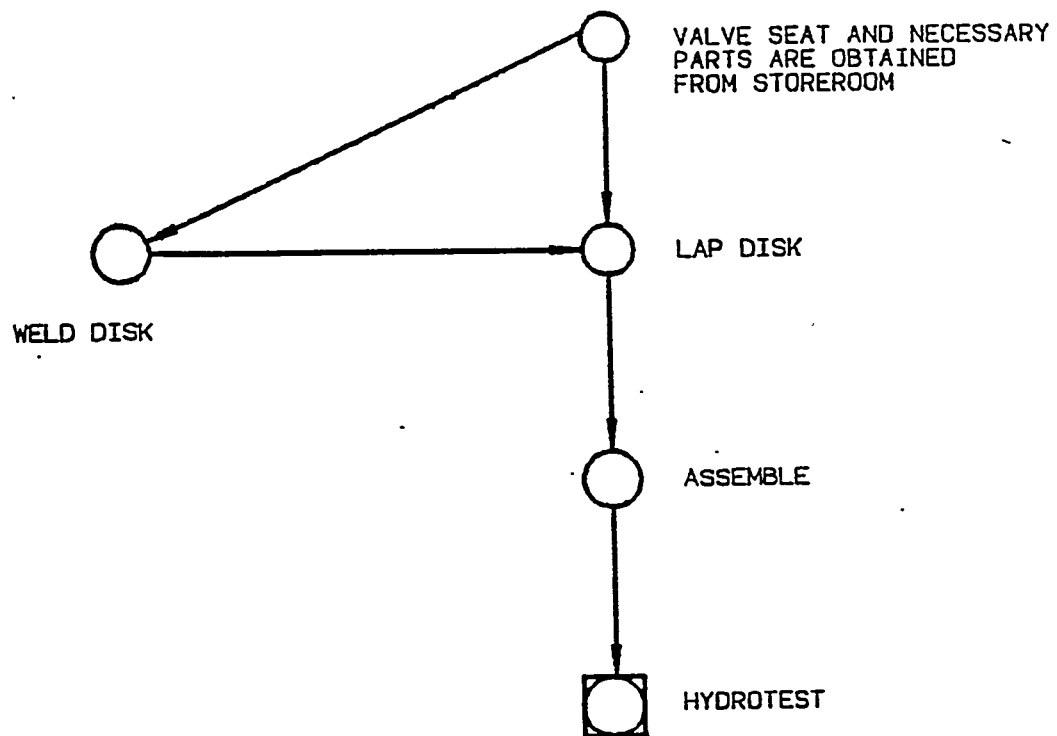
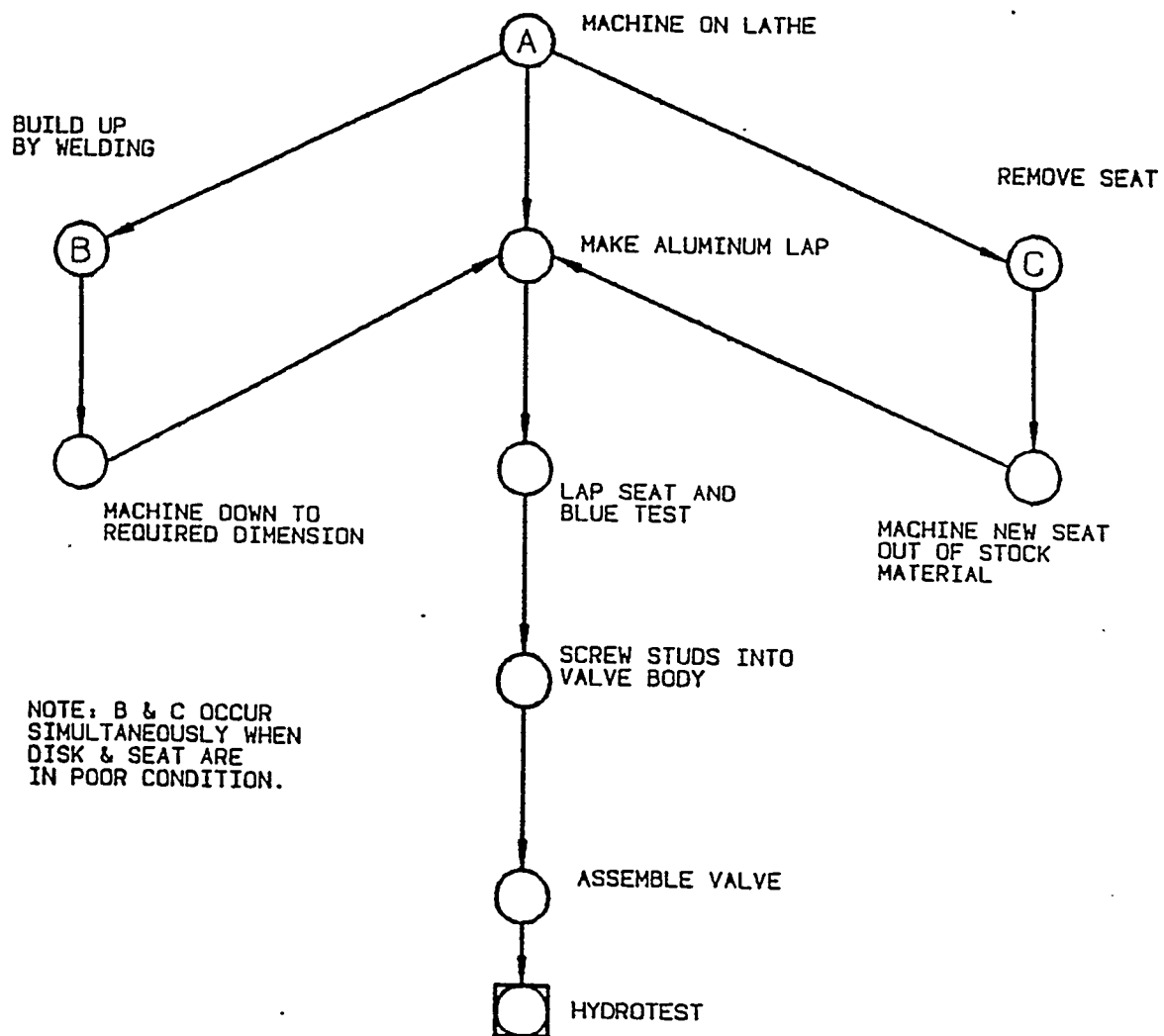


FIG. 1B

# FLOW CHART FOR THE REPAIR OF GLOBE VALVES

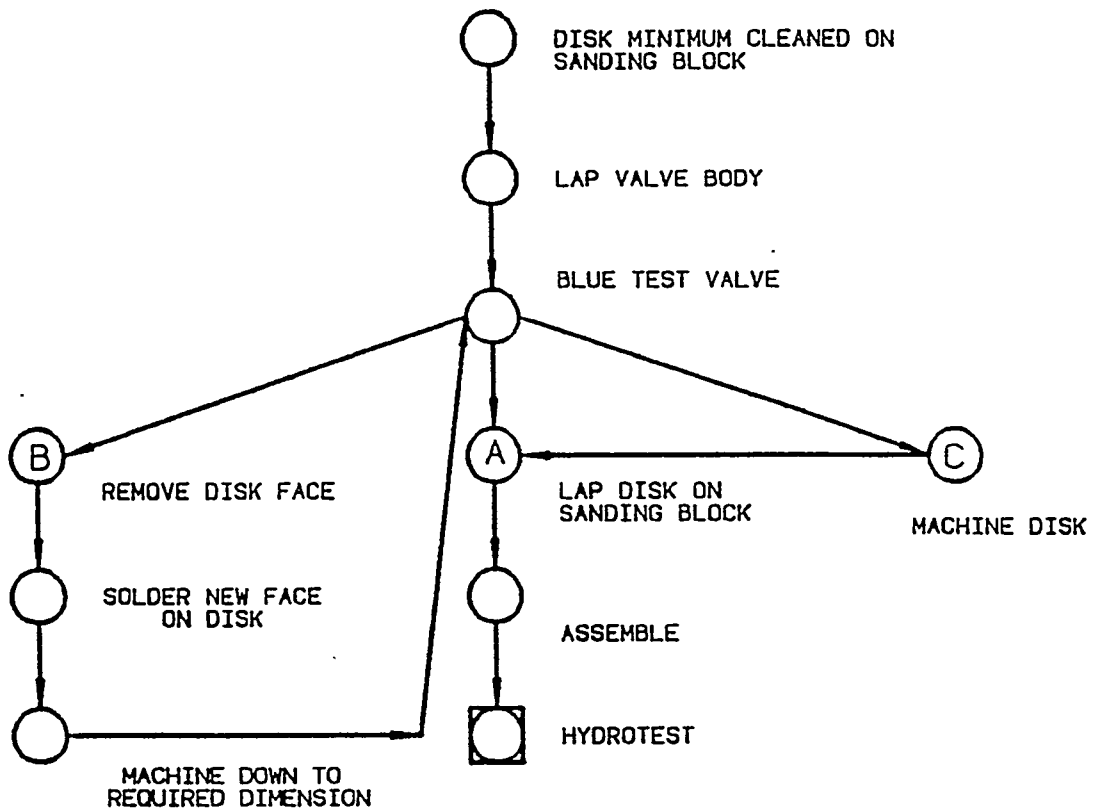


## IR SHOP REPAIRABLE CONDITIONS

- A. VALVE DISK AND SEAT IN GOOD CONDITION.
- B. SEAT IN POOR CONDITION.
- C. DISK IN POOR CONDITION.

FIG. 1C

## FLOW CHART FOR THE REPAIR OF GATE VALVES



## IR SHOP REPAIRABLE CONDITIONS

- A. VALVE DISK AND SEAT IN GOOD CONDITION
- B. MACHINING WILL ALLOW AN ACCEPTABLE BLUE TEST.
- C. MACHINING WILL GIVE AN UNACCEPTABLE BLUE TEST

FIG. 1D

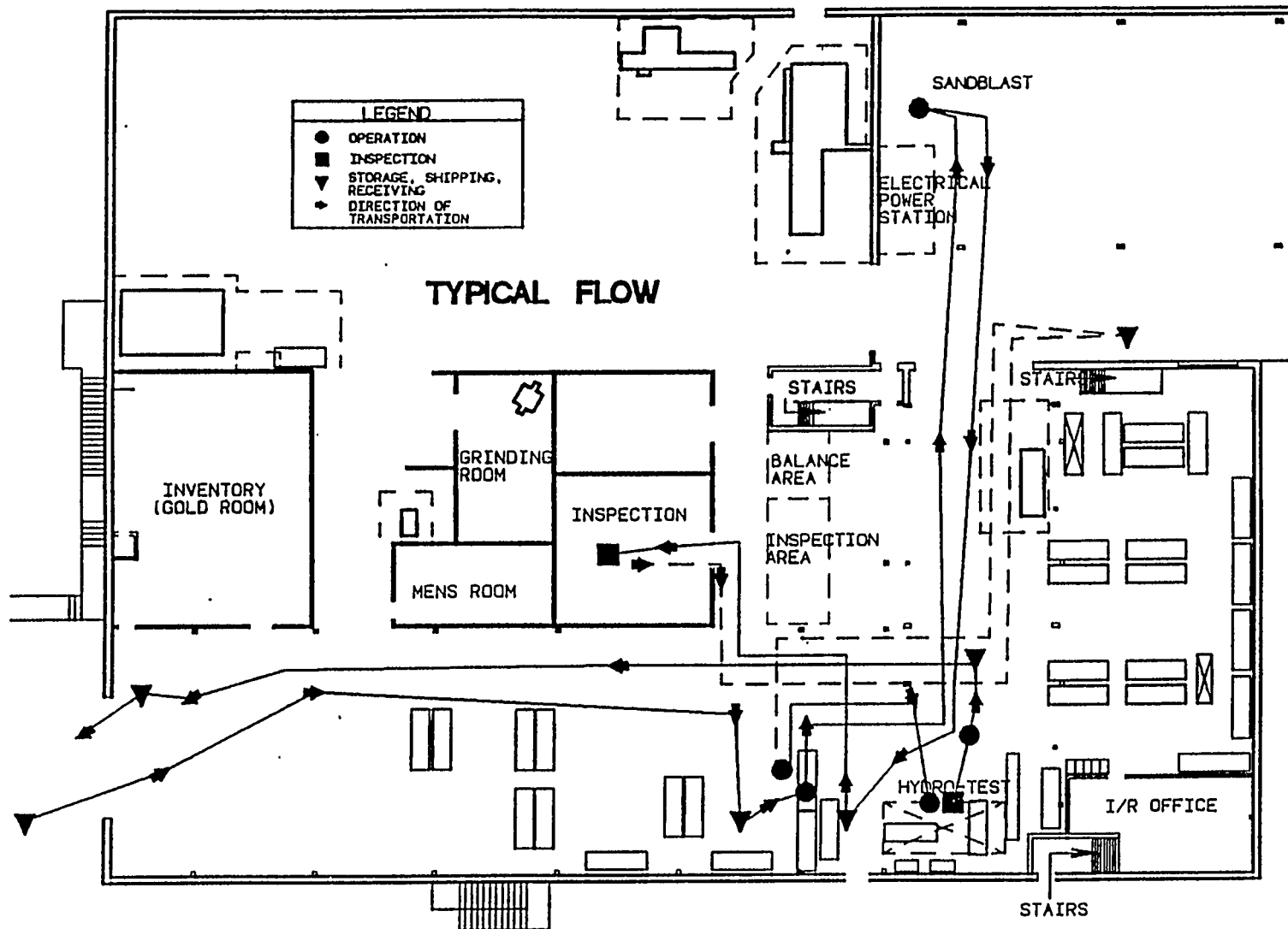


FIG. 2

There were very good reasons for certain existing conditions, such as the Sand Blast Operation.

- (1) The grit blast contaminates work areas and requires proper control and venting.
- (2) Others use the operation.
- (3) The operation just doesn't fit (dissimilar) with machine and repair operations.

This one example is classic to the challenge of GT application. You must find ways to make the "ugly duckling" acceptable.

Material movement and handling when properly studied and analyzed will pinpoint problems and supply impact. Here the plan view layout is as strong as the quantitative analysis in stressing problem areas.

As might be expected, certain operations performed manually were considered for mechanization, and these possibilities needed to be included in the cellular plan. Also, to be included in the plan was a modernized valve test system that can afford high rate production for standard type valves but also provide special setup and test of the large or uncommon valve.

When any study starts to show clear results, several things should happen:

- (1) The Engineer will start to see the "missing" links that prompt additional study or even suggest some limitations in the project scope.
- (2) The results should be communicated to all involved, particularly the Area Manager.
- (3) "Givens, assumptions, and economic limitations" should be reviewed and corrections made and impacts considered.

These and other steps should be acted upon along with consideration of the cellular plan.

**PROPOSED CELLULAR PLAN:** All data and findings were taken into consideration and an ideal layout was developed along with concepts of work stations. This approach was used to permit the best ideas to emerge even though it was understood that certain physical and economic limitations had to be recognized later. Refer to Figure 3A, 3B, and 3C.

The ideal layout stresses the interrelationship of the operations and desired physical proximity. A circular or square flow pattern would fit very nicely.

# IDEAL LAYOUT

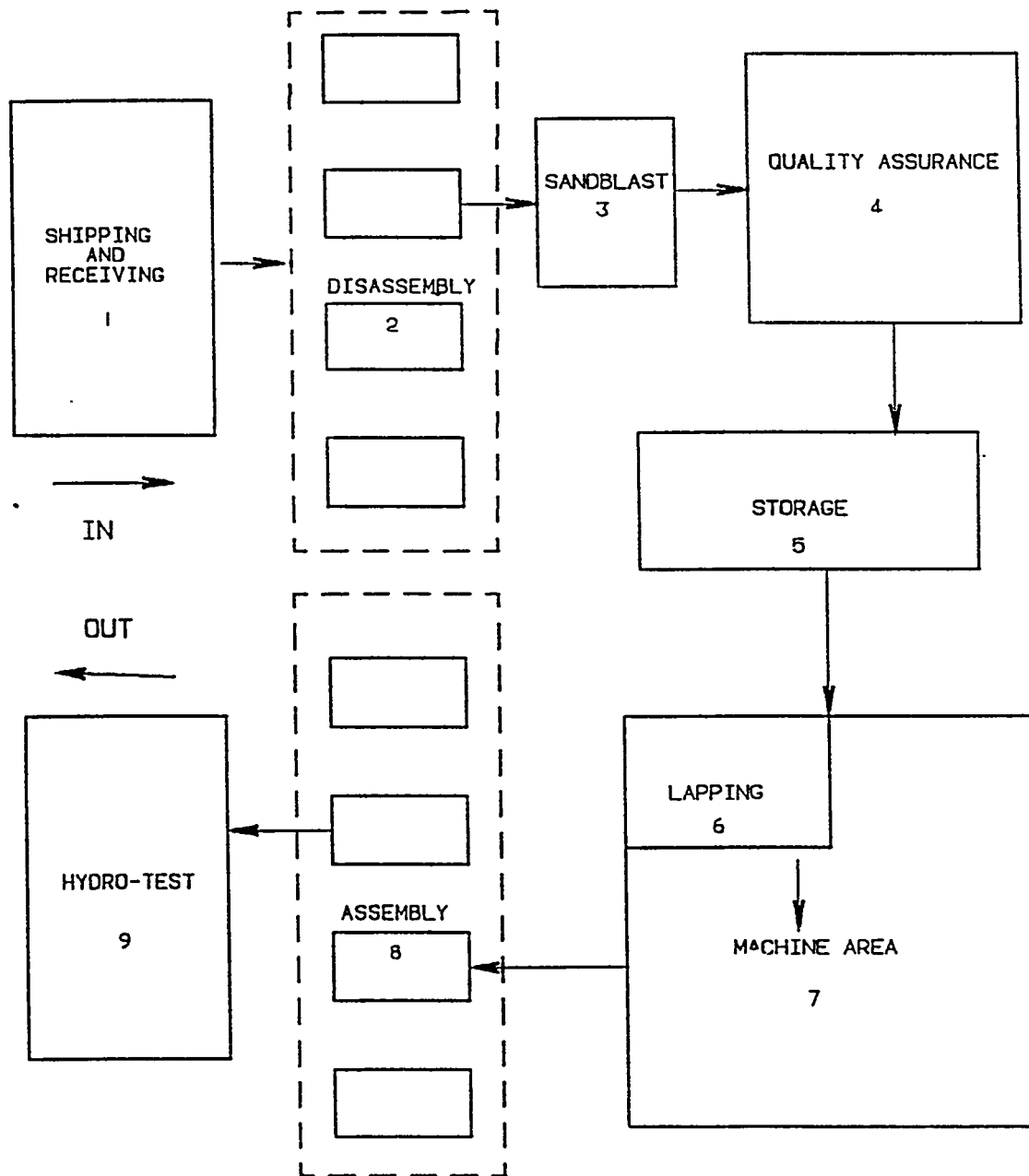
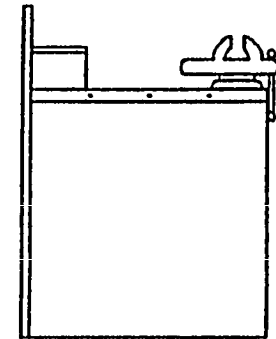
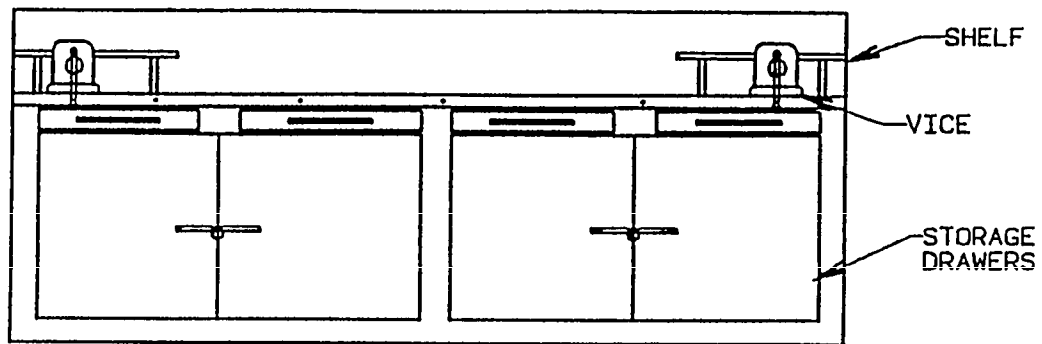
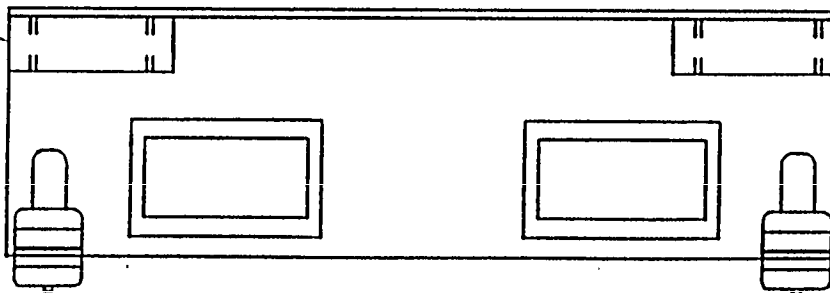


FIG. 3A



### ITEMS WHICH SHOULD BE AT EVERY BENCH

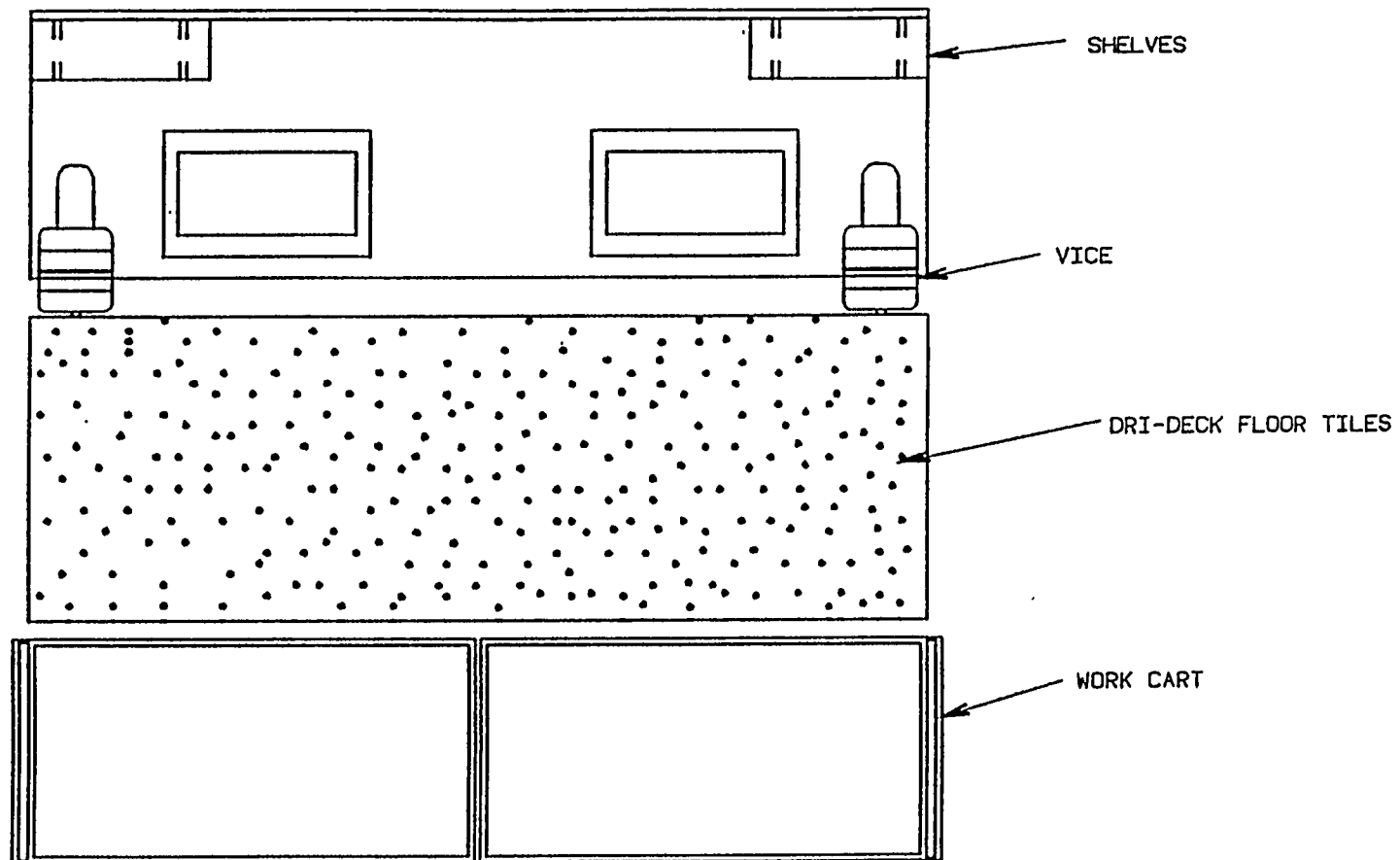
PENETRATING OIL (TAPMATIC)  
 ACETONE  
 ALUMICUT  
 NEVER SEEZE  
 GENERAL PURPOSE GREASE  
 SUPER 77 SPRAY ADHESIVE  
 SANDPAPER ALL GRADES  
 PRUSSIAN BLUE  
 RTV ADHESIVE SEALANT  
 DYKEM SPRAY REMOVER  
 RAGS



### IDEAL WORKBENCH

FIG. 3B





VALVE WORK CELL

FIG. 3C

The cellular concept lends itself to the ideal by definition. However, even in a new plant construction project some "real world" limitation presents itself. Most often it will be an economic limit. None-the-less, an ideal layout is recommended if only to lay emphasis for the Engineer or a reference in communicating to those involved. This will also form a "baseline" to measure from when assessing the actual proposals that will be designed.

The practical conditions imposed by the present factory space, e.g., the location of the hydro-test with a permanent slump and drain, were added to the requirements and a final proposal developed (Figure 4A).

The plan calls for a new Sand Blast Bay (reducing travel as much as 78%), a Modular Storage System (Figure 4B), that utilizes what otherwise is very poor floor space to reduce handling and travel, improved work station design, and a new Lapping Station. We call for revisions of the layout for entry storage, in-process flow and cell support machines (lathe, sander, broach and drill press).

The general shop facility, Hydro-test and Inspection Bay are not changed.

Refer to the analyses of Globe Valve Travel and Repair Time. Travel is reduced an overall 57% and repair cycle time, 70%. These are reductions for this specific type valve and condition. We estimate the product mix would travel but a more moderate 25% to 35% reduction in overall average cycle times.

We found that a number of existing plan conditions required very little change in order to meet the new cellular concept. On the other hand, those cellular flow requirements that needed to be introduced will represent a sizeable capital investment.

It should not be surprising in many cellular studies to find that existing conditions already are within Group Technology guidelines. This should be an encouragement for further change or modification. However, it might also be found that the condition exists for the wrong reasons or that it did not go far enough to meet current needs.

These studies reveal that many cellular arrangements lend themselves to periodic update, change and revision. Try to build these considerations into the design of the cell and make these known for further planning, as well as good cellular maintenance.

**FIG. 4A**

# Carousel Drive System

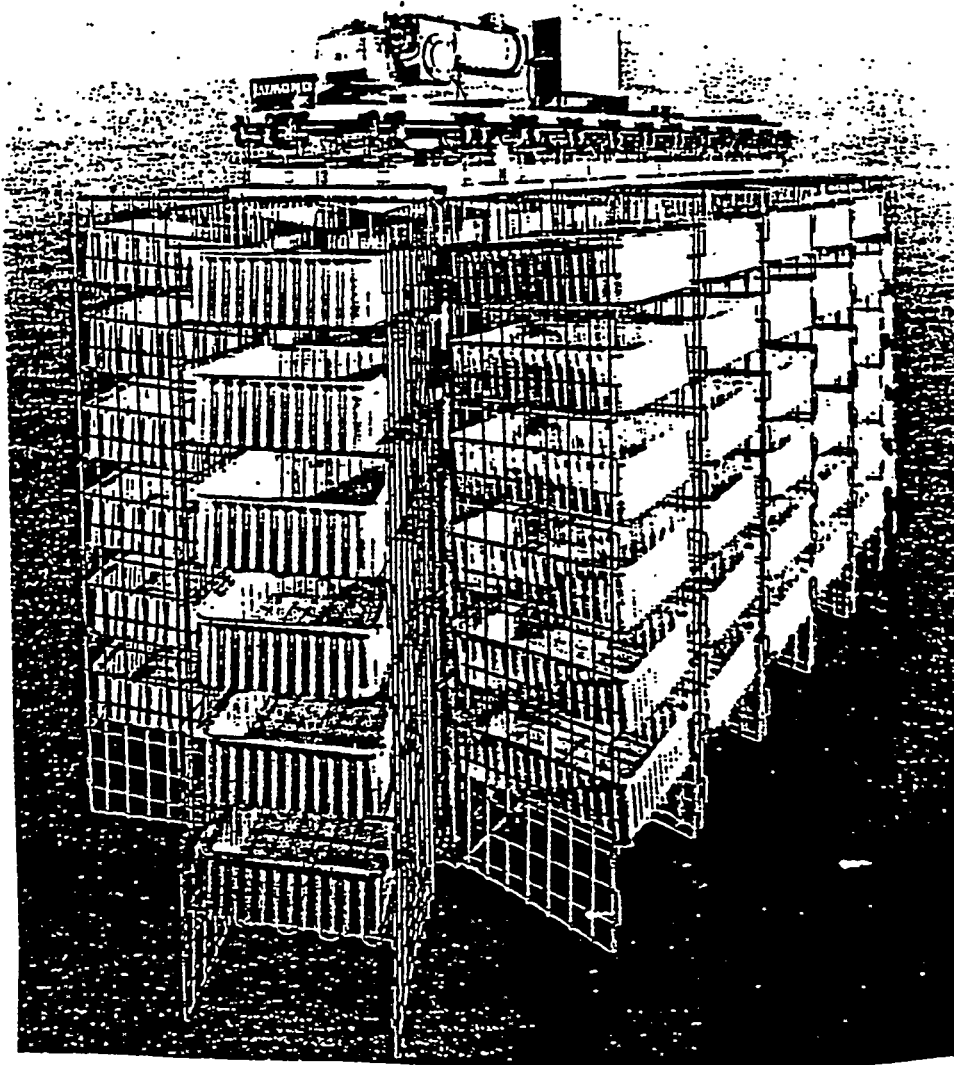


FIG. 4B

**CONCLUSION** The current proposal has been presented to shop management. After further consultation, necessary revisions, and agreement it will be presented to executive management for approval and budgeting. Once implemented the new cell will offer the following:

1. Improve flow and movement of material.
2. Improve in-process storage.
3. Mechanize lapping.
4. High rate and better testing.
5. Improve grit blast operations
6. Closer supervision and production control.
7. Increase standardized work procedures.
8. Production rate increase of 25% to 30%.
9. Maintenance of flexibility.

A final comment for all who see a Group Technology cellular application in their shipyard or support facility:

Vincent F. Bobrowicz (our resource person at the seminar) has presented many Group Technology training courses and workshops where it is stressed . . . .

"Group Technology is not a science with precise formulas, but rather is a tool to be developed in each distinct facility."